Valence-Shell Electron-Pair Repulsion (VSEPR) Theory

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YALE UNIVERSITY
CHEMISTRY 161
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VSEPR Principles

1. Electrons are negatively charged.
2. Because of their negative charge, electrons want to spread out as much as possible. (i.e. they repel).
3. Valence electrons around a central atom minimize repulsion between themselves.

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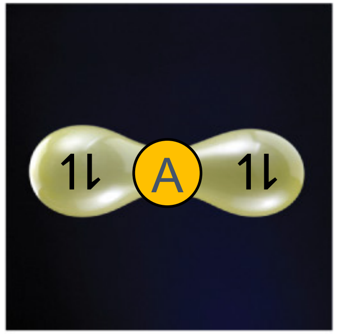
Imagine electron pairs (1⇂) as the yellow balloon-like lobes around a central atom A.
If we had two electron pairs (1⇂, 1⇂), they would spread out linearly about A.



# of electron pairs: 2

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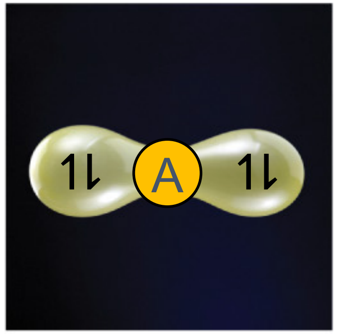

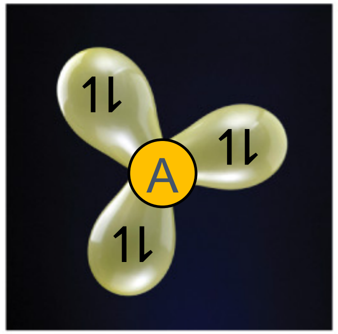

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Imagine electron pairs (↿⇂) as the yellow balloon-like lobes around a central atom A.
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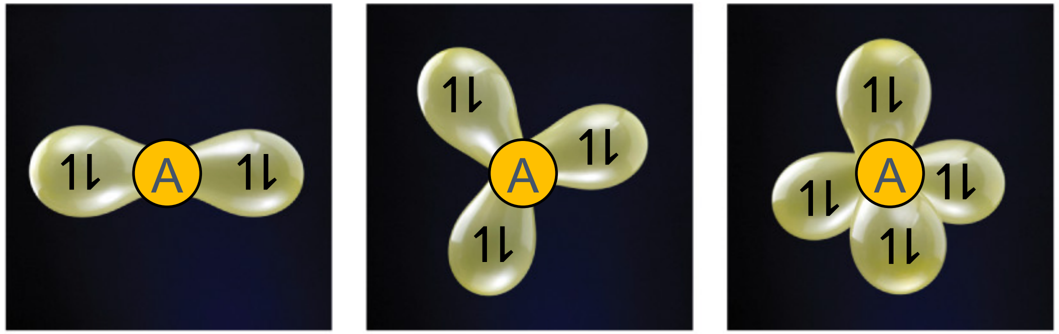
If we had <u>four</u> electron pairs (↿⇂, ↿⇂ , ↿⇂), they would spread out <u>tetrahedrally</u> about A.



# of electron pairs: 2 3 4

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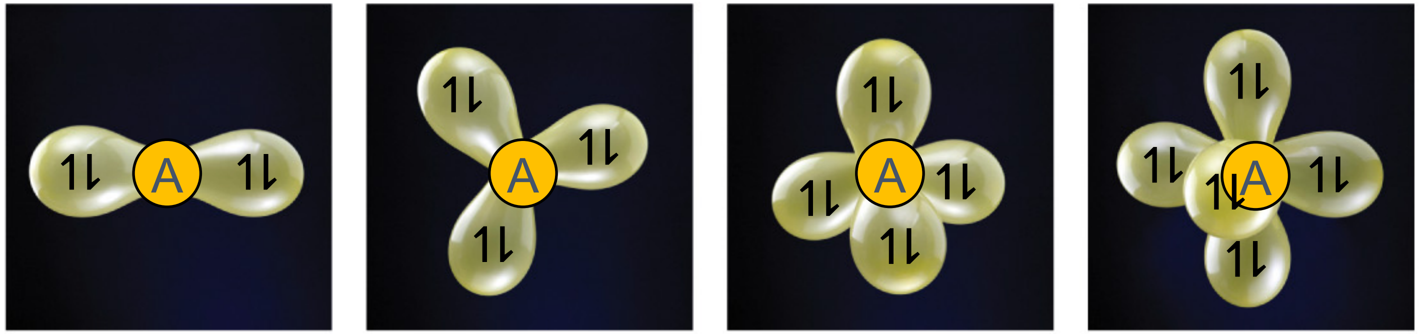
If we had <u>five</u> electron pairs (↿⇂, ↿⇂ , ↿⇂), they would spread out <u>bi-pyramidally</u> about A.



# of electron pairs: 2 3 4 5

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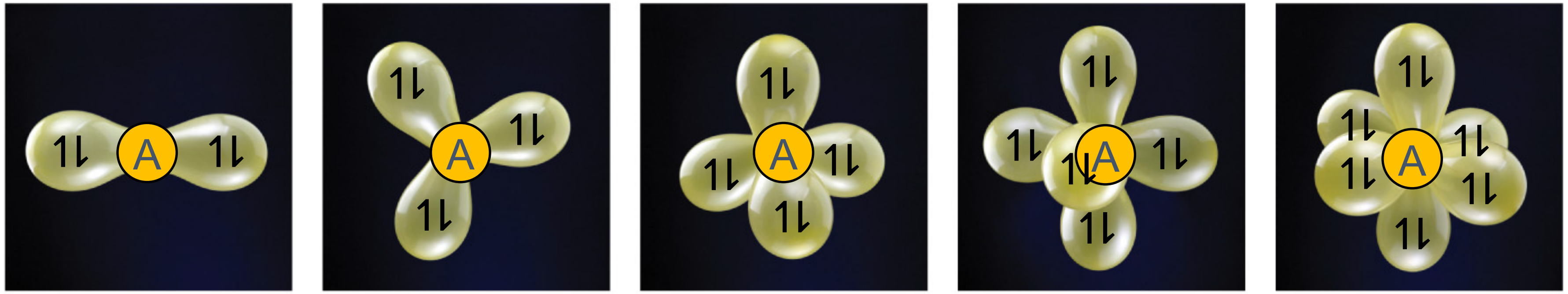
If we had six electron pairs (↿⇂, ↿⇂ , ↿⇂), they would spread out octahedrally about A.



# of electron pairs: 2 3 4 5 6

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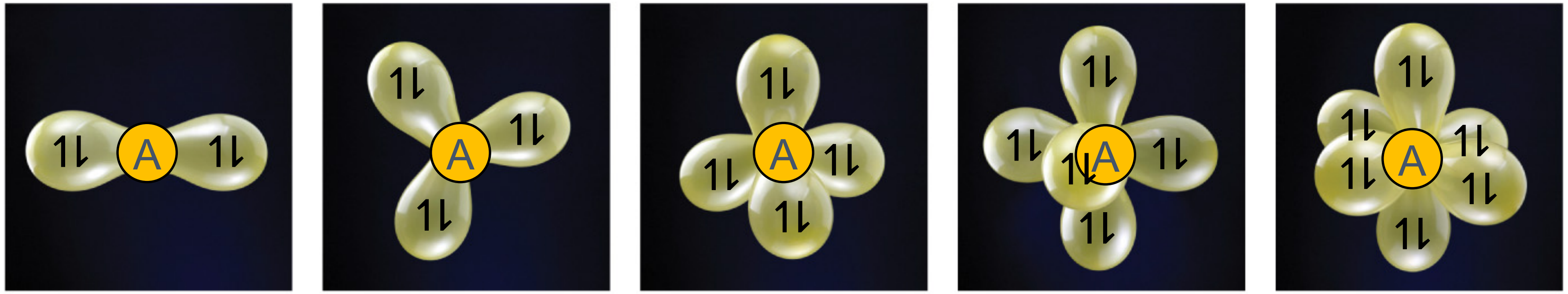

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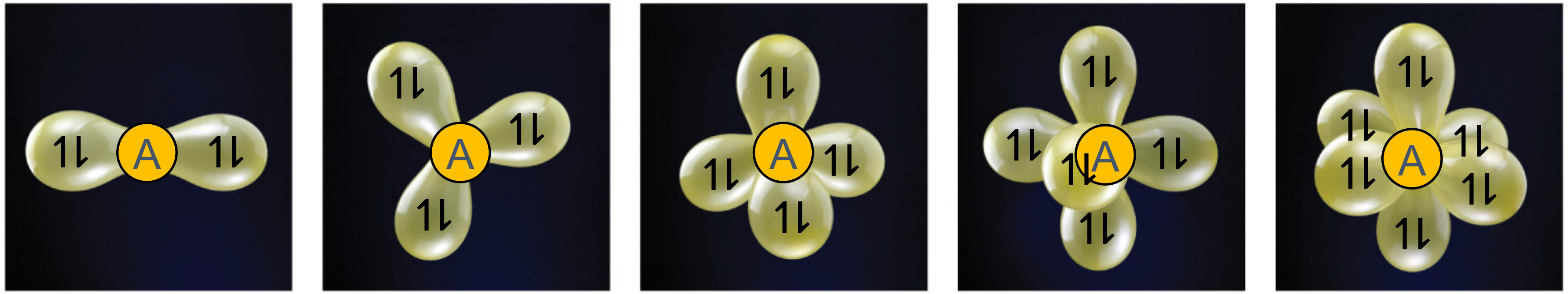

SN = 2 3 4 5 6

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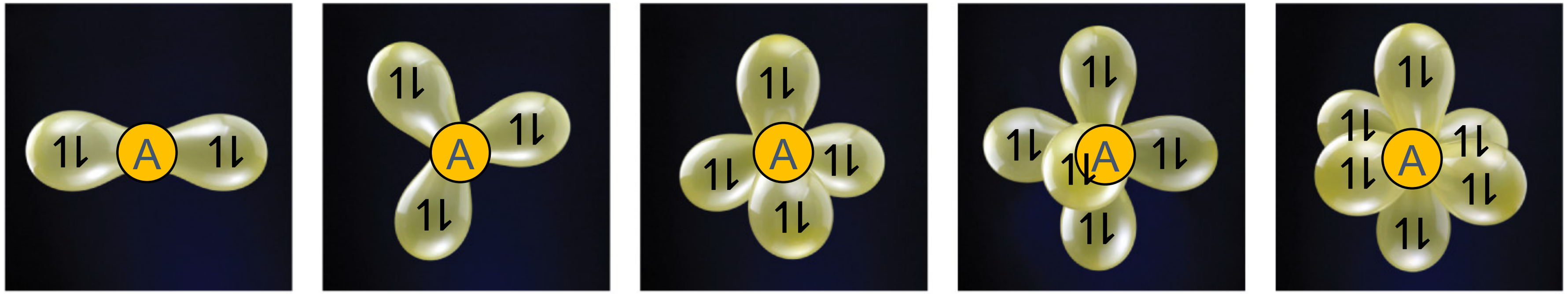
Determine the SN for each:

SF_4 H_2O CH_4

CO_2 SO_2 XeF_2



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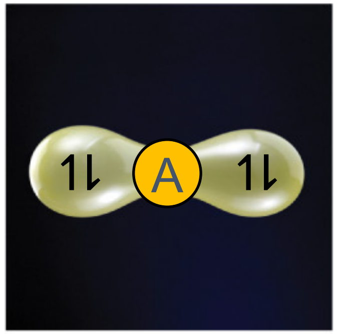

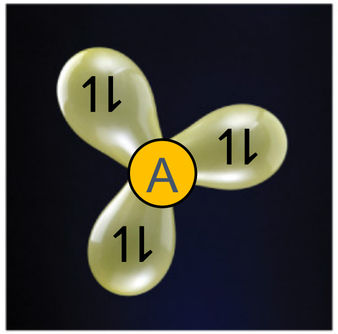

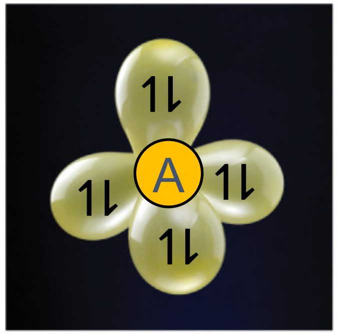

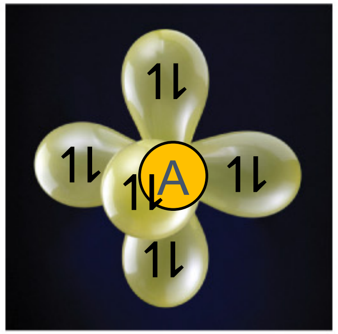

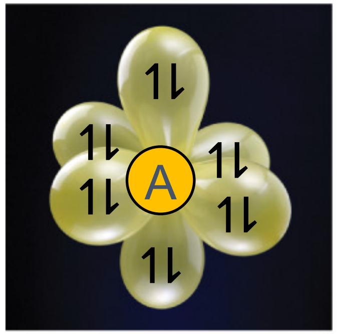

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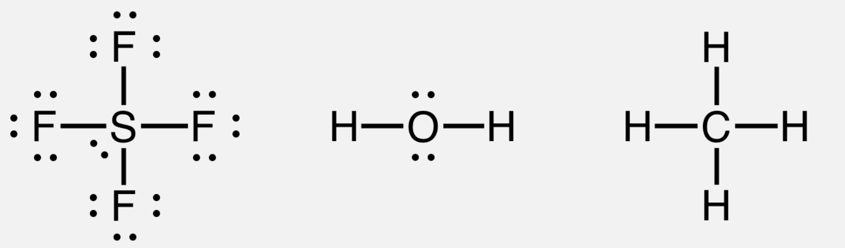
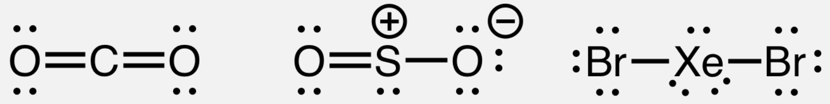
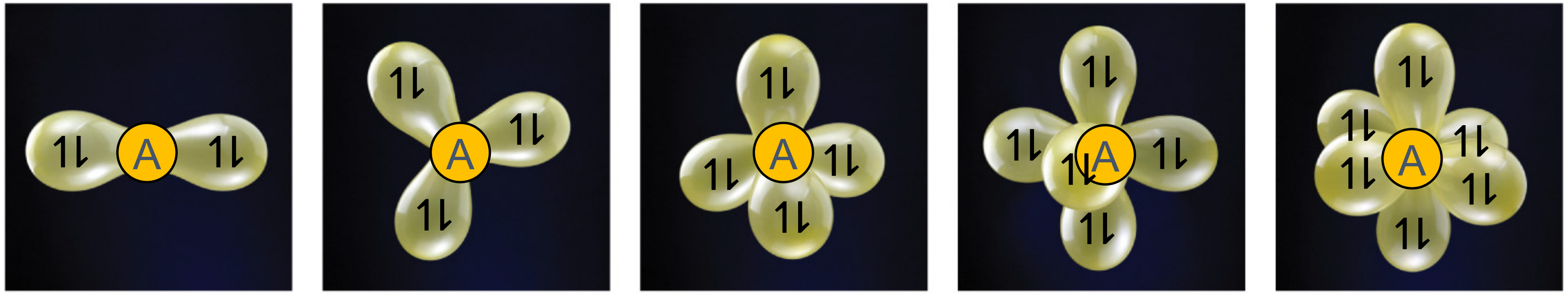


CO_2 SO_2 XeF_2





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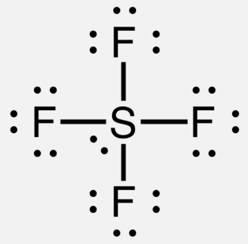

SN = SN = SN =

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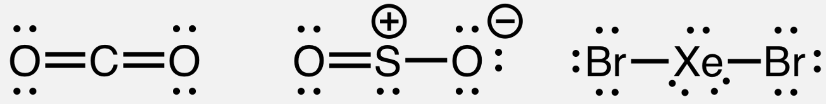

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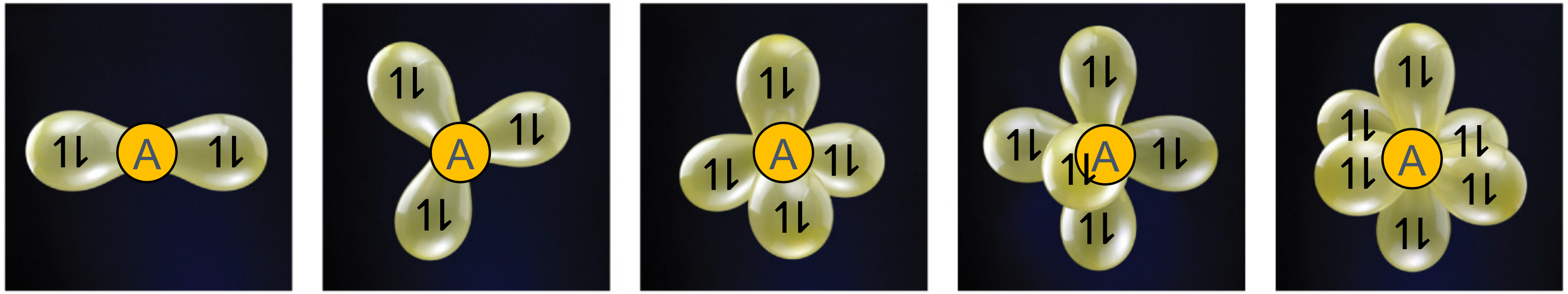

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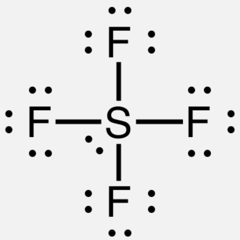
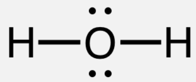
SF_4



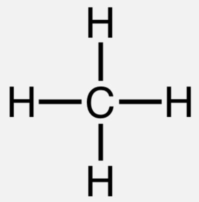
SN = 5

H_2O



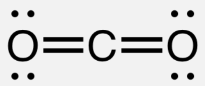
SN = 4

CH_4



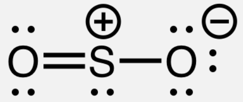
SN = 4

CO_2



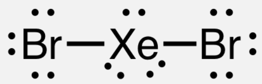
SN = 2

SO_2



SN = 3

XeF_2



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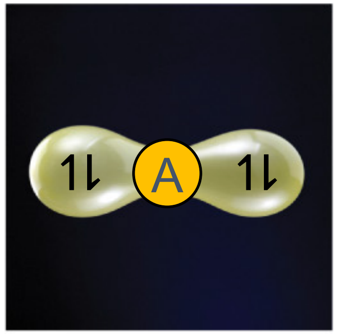

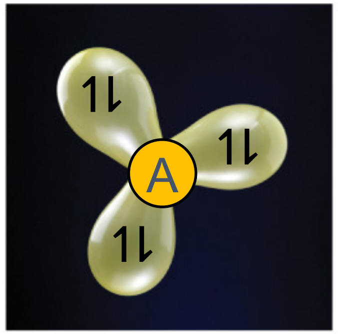

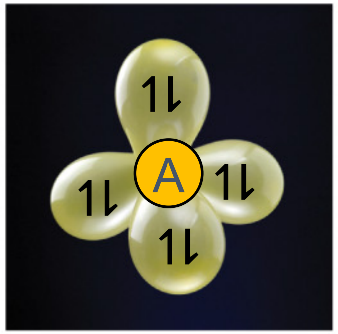

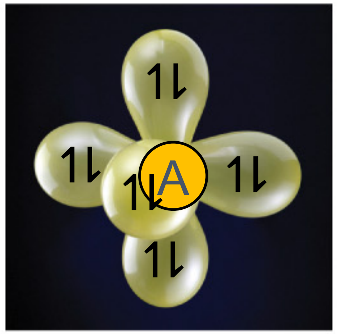

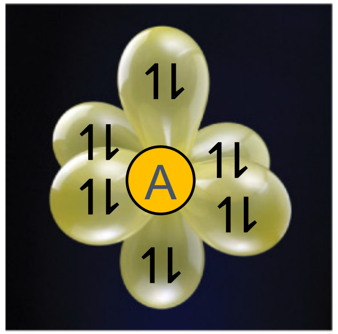

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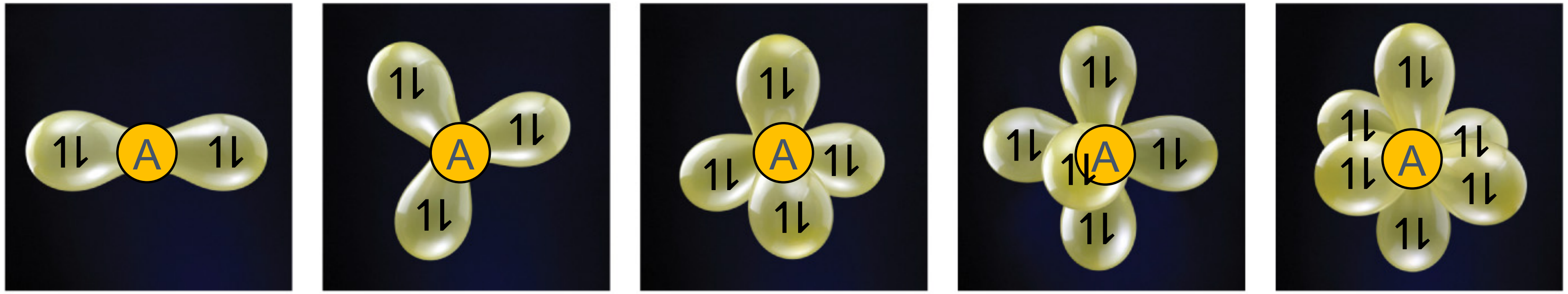

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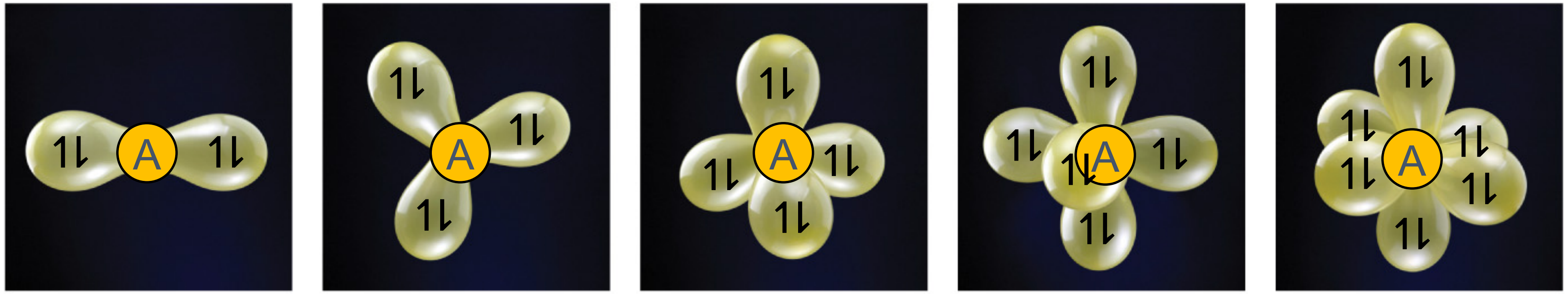
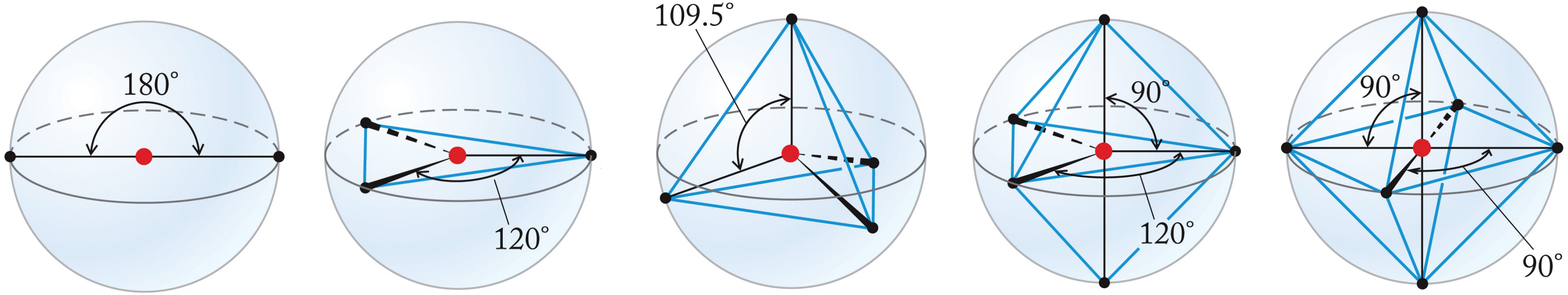


SN = 2 LINEAR | 3 TRIGONAL PLANAR | 4 TETRAHEDRAL | 5 TRIGONAL BIPYRAMID | 6 OCTAHEDRAL

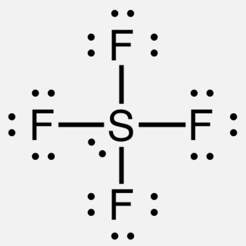


HOW TO FIND THE MOLECULAR GEOMETRY

Find the steric number (SN) about the central atom. ➡

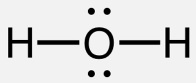
Determine the molecular geometry of each:

SF_4



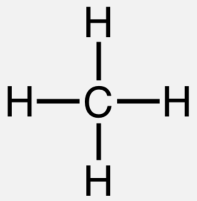
SN = 5

H_2O



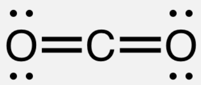
SN = 4

CH_4



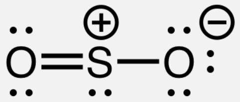
SN = 4

CO_2



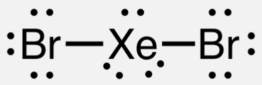
SN = 2

SO_2



SN = 3

$XeBr_2$



SN = 5

HOW TO FIND THE MOLECULAR GEOMETRY

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Determine the molecular geometry of each:

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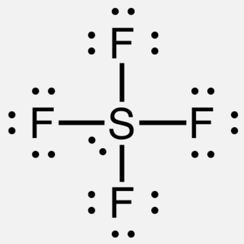

SN = 5

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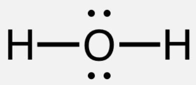

SN = 4

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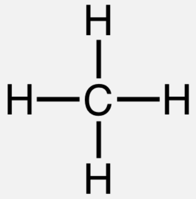

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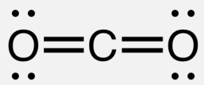

SN = 2

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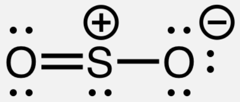

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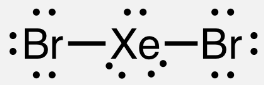


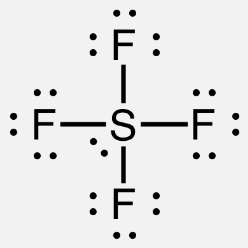
SN = 5

HOW TO FIND THE MOLECULAR GEOMETRY

Find the steric number (SN) about the central atom. ➡ From the SN value, determine the electron-pair geometry. ➡ If no lone pairs, then electron-pair geometry = molecular geometry.

Determine the molecular geometry of each:

SF_4



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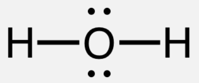

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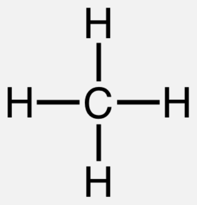

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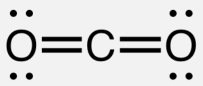
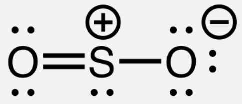


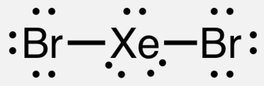
SN = 2

SO_2



SN = 3

$XeBr_2$



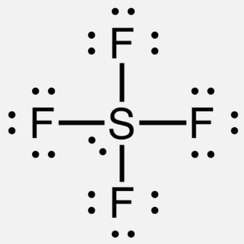
SN = 5

HOW TO FIND THE MOLECULAR GEOMETRY

Find the steric number (SN) about the central atom. ➡ From the SN value, determine the electron-pair geometry. ➡ If no lone pairs, then electron-pair geometry = molecular geometry.

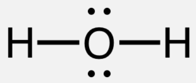
Determine the molecular geometry of each:

SF_4



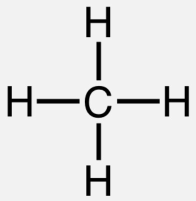
SN = 5

H_2O



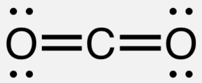
SN = 4

CH_4



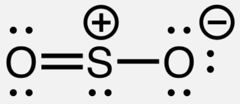
SN = 4, tetrahedral

CO_2



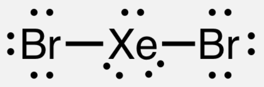
SN = 2, linear

SO_2



SN = 3

$XeBr_2$



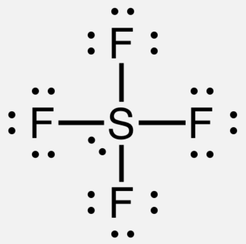
SN = 5

HOW TO FIND THE MOLECULAR GEOMETRY

Find the steric number (SN) about the central atom. ➡ From the SN value, determine the electron-pair geometry. ➡ If no lone pairs, then electron-pair geometry = molecular geometry.

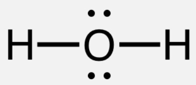
Determine the molecular geometry of each:

SF_4



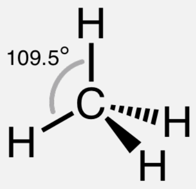
SN = 5

H_2O



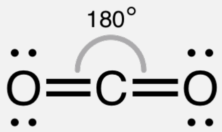
SN = 4

CH_4



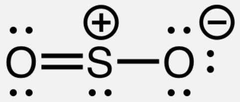
SN = 4, tetrahedral

CO_2



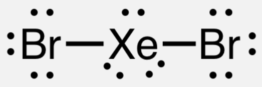
SN = 2, linear

SO_2



SN = 3

$XeBr_2$



SN = 5

Let's redraw these to reflect the molecular geometry.

HOW TO FIND THE MOLECULAR GEOMETRY

Find the steric number (SN) about the central atom. ➡ From the SN value, determine the electron-pair geometry. ➡ If no lone pairs, then electron-pair geometry = molecular geometry.

Let's redraw these to reflect the molecular geometry.

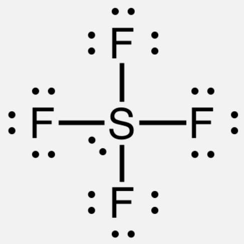
➡ If lone pairs, then place lone pair to minimize interactions.

⬇

And then find molecular geometry.

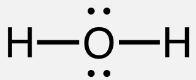
Determine the molecular geometry of each:

SF_4



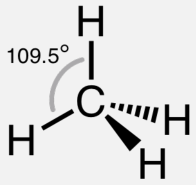
SN = 5

H_2O



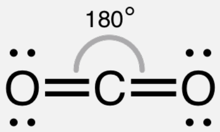
SN = 4

CH_4



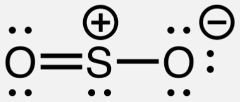
SN = 4, tetrahedral

CO_2



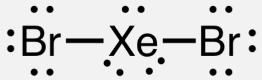
SN = 2, linear

SO_2



SN = 3

$XeBr_2$



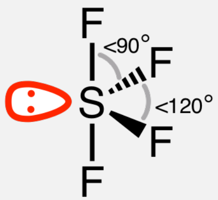
SN = 5

HOW TO FIND THE MOLECULAR GEOMETRY

Find the steric number (SN) about the central atom. → From the SN value, determine the electron-pair geometry. → If no lone pairs, then electron-pair geometry = molecular geometry.

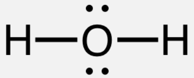
Determine the molecular geometry of each:

SF_4



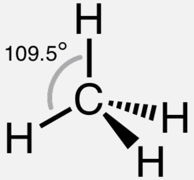
SN = 5

H_2O



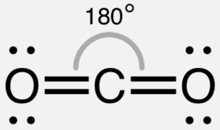
SN = 4

CH_4



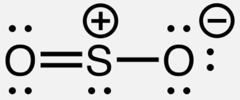
SN = 4, tetrahedral

CO_2



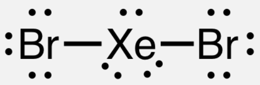
SN = 2, linear

SO_2



SN = 3

$XeBr_2$



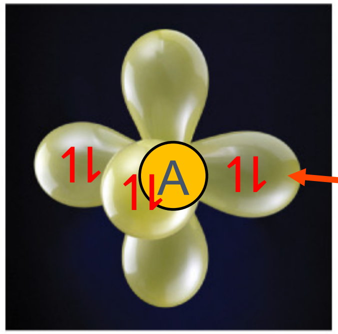
SN = 5

Let's redraw these to reflect the molecular geometry.

→ If lone pairs, then place lone pair to minimize interactions.

↓

And then find molecular geometry.



SN = 5

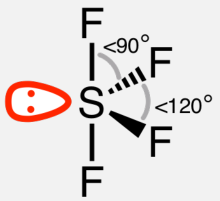
Would be best to put lone pair electrons (1⇂) in one of these three positions for SN = 5.

HOW TO FIND THE MOLECULAR GEOMETRY

Find the steric number (SN) about the central atom. ➡ From the SN value, determine the electron-pair geometry. ➡ If no lone pairs, then electron-pair geometry = molecular geometry.

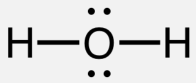
Determine the molecular geometry of each:

SF_4



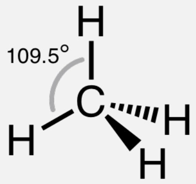
SN = 5, see-saw

H_2O



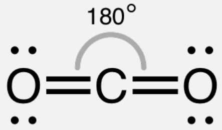
SN = 4

CH_4



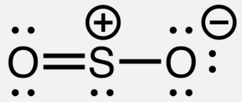
SN = 4, tetrahedral

CO_2



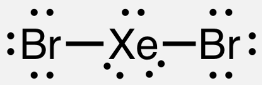
SN = 2, linear

SO_2



SN = 3

$XeBr_2$



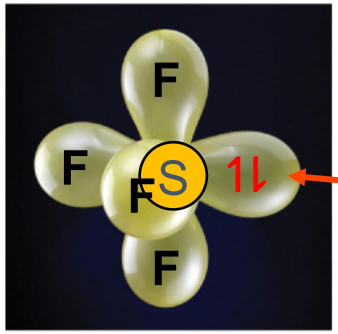
SN = 5

Let's redraw these to reflect the molecular geometry.

➡ If lone pairs, then place lone pair to minimize interactions.

⬇

And then find molecular geometry.



SN = 5

Would be best to put lone pair electrons (1⇂) in one of these three positions for SN = 5.

HOW TO FIND THE MOLECULAR GEOMETRY

Find the steric number (SN) about the central atom. → From the SN value, determine the electron-pair geometry. → If no lone pairs, then electron-pair geometry = molecular geometry.

Let's redraw these to reflect the molecular geometry.

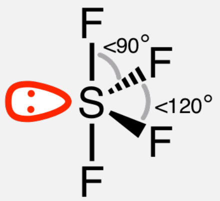
→ If lone pairs, then place lone pair to minimize interactions.

↓

And then find molecular geometry.

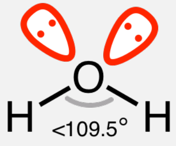
Determine the molecular geometry of each:

SF_4



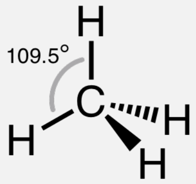
SN = 5, see-saw

H_2O



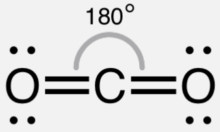
SN = 4, bent

CH_4



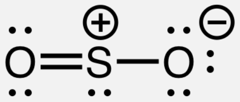
SN = 4, tetrahedral

CO_2



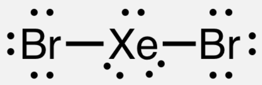
SN = 2, linear

SO_2

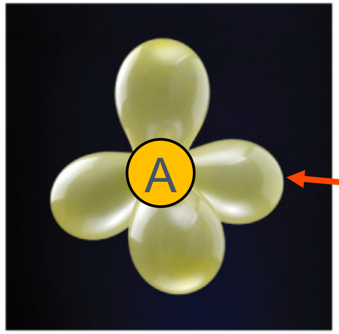


SN = 3

$XeBr_2$



SN = 5



SN = 4

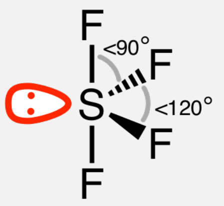
You can put the lone pair electrons (↿⇂) in any of these four positions for SN = 4.

HOW TO FIND THE MOLECULAR GEOMETRY

Find the steric number (SN) about the central atom. ➡ From the SN value, determine the electron-pair geometry. ➡ If no lone pairs, then electron-pair geometry = molecular geometry.

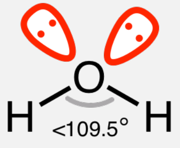
Determine the molecular geometry of each:

SF_4



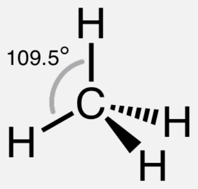
SN = 5, see-saw

H_2O



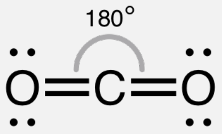
SN = 4, bent

CH_4



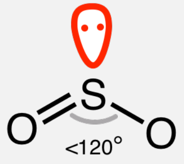
SN = 4, tetrahedral

CO_2



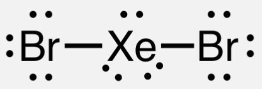
SN = 2, linear

SO_2



SN = 3, bent

$XeBr_2$



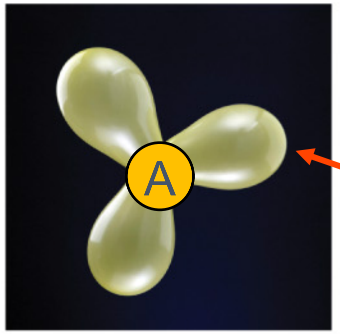
SN = 5

Let's redraw these to reflect the molecular geometry.

➡ If lone pairs, then place lone pair to minimize interactions.

⬇

And then find molecular geometry.



SN = 3

You can put the lone pair electrons (↿⇂) in any of these three positions for SN = 3.

HOW TO FIND THE MOLECULAR GEOMETRY

Find the steric number (SN) about the central atom. ➡ From the SN value, determine the electron-pair geometry. ➡ If no lone pairs, then electron-pair geometry = molecular geometry.

Let's redraw these to reflect the molecular geometry.

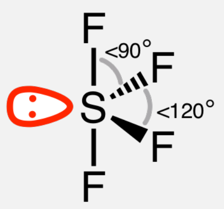
➡ If lone pairs, then place lone pair to minimize interactions.

⬇

And then find molecular geometry.

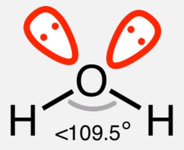
Determine the molecular geometry of each:

SF_4



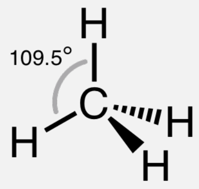
SN = 5, see-saw

H_2O



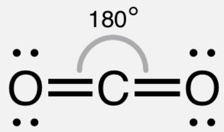
SN = 4, bent

CH_4



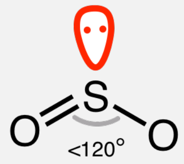
SN = 4, tetrahedral

CO_2



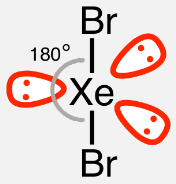
SN = 2, linear

SO_2

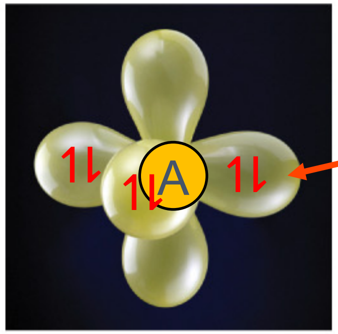


SN = 3, bent

$XeBr_2$



SN = 5, linear



SN = 5

Would be best to put the three lone pair electrons (1⇂) in these three positions for SN = 5.