

BERKELEY MATH CIRCLE

**The Math of Chemistry:
Building Molecules
&
Their Geometric Shapes
Part III**

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Rules from 1st Lecture

Ground Rules	Number of Electrons Drawn	Dot Diagrams
<ul style="list-style-type: none"> Octet Rule (except Hydrogen) Single Bonds Double Bonds Triple Bonds Lone Pairs 	<ul style="list-style-type: none"> Obtained from the Periodic Table Column's 1-8 = # of e's 	<ul style="list-style-type: none"> Four sides to our atom symbol One dot per side first After, electrons can be paired

Periodic Table of the Elements

1 1A 11A H Hydrogen 1.008	2 2A 2A Be Beryllium 9.012											13 3A 3A B Boron 10.811	14 4A 4A C Carbon 12.011	15 5A 5A N Nitrogen 14.007	16 6A 6A O Oxygen 15.999	17 7A 7A F Fluorine 18.998	18 8A 8A He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012	3 3B 3B	4 4B 4B	5 5B 5B	6 6B 6B	7 7B 7B	8 VIII 8	9 VIII 8	10 VIII 8	11 1B 1B	12 2B 2B	5 Al Aluminum 26.982	6 Si Silicon 28.086	7 P Phosphorus 30.974	8 S Sulfur 32.066	9 Cl Chlorine 35.453	10 Ar Argon 39.948
11 Na Sodium 22.990	12 Mg Magnesium 24.305	21 Sc Scandium 44.956	22 Ti Titanium 47.88	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.933	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.732	32 Ge Germanium 72.61	33 As Arsenic 74.922	34 Se Selenium 78.09	35 Br Bromine 79.904	36 Kr Krypton 84.80
37 Rb Rubidium 84.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.94	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.71	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.29
55 Cs Cesium 132.905	56 Ba Barium 137.327	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.967	80 Hg Mercury 200.59	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [208.982]	85 At Astatine 209.987	86 Rn Radon 222.018
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [269]	111 Rg Roentgenium [272]	112 Cn Copernicium [277]	113 Uut Ununtrium unknown	114 Fl Flerovium [289]	115 Uup Ununpentium unknown	116 Lv Livermorium [298]	117 Uus Ununseptium unknown	118 Uuo Ununoctium unknown

VSEPR Theory Review

VSEPR Theory = Valence **S**hell **E**lectron **P**air **R**epulsion Theory

Electrons REPEL each other since they are negatively charged. Therefore, bonds repel each other since they contain electrons. Similarly, electron pairs, that can be found on atoms, also repel bonds and other electron pairs. All bonds (single, double, triple) and electron pairs that are attached to the same central atom need to simultaneously repel each other and stay attached!

Rules from 2nd Lecture

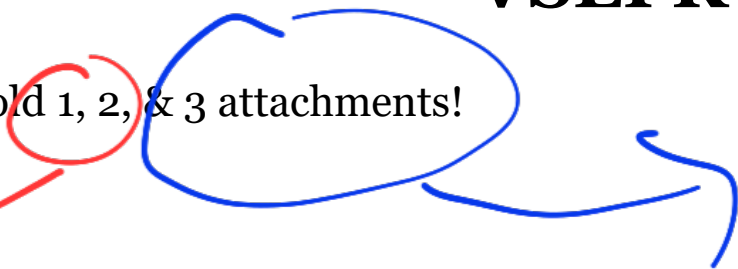


1. Identify your central atom (more than one can exist!).
2. COUNT how many separate attachments are on THAT atom.
3. One attachment = single bond, double bond, triple bond, or an electron pair. *
4. EACH one of these counts as ONE attachment!
5. Place all attachments around your central atom in a way that MINIMIZES their interaction while SIMULTANEOUSLY staying attached. 2D and 3D options may exist.

VSEPR Shapes!

Let's review how to hold 1, 2, & 3 attachments!

Linear



Let's review how to hold 4 attachments!

↳ camera w/ tripod →



Let's review how to hold 5 attachments!

↳ tetrahedral

Let's review how to hold 6 attachments!

NOW, let's explore if some of those attachments are electron pairs instead of bonds!

H₂



180°

Linear

1 attachment

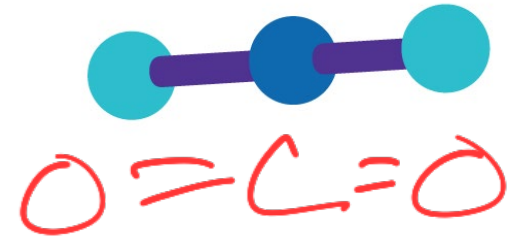


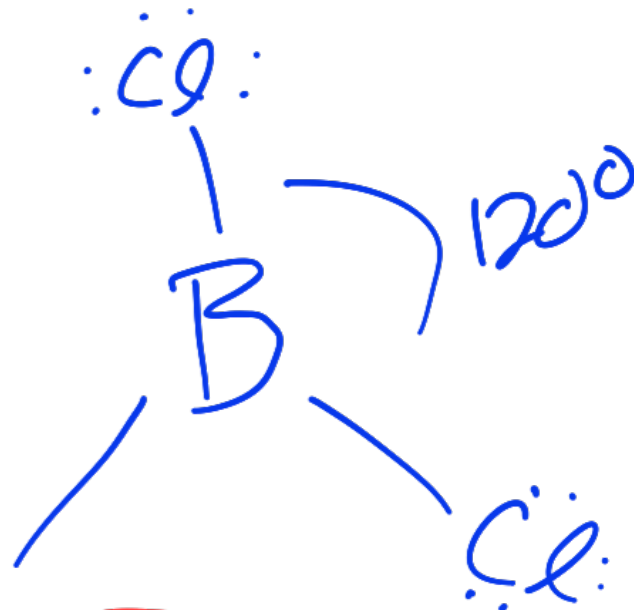
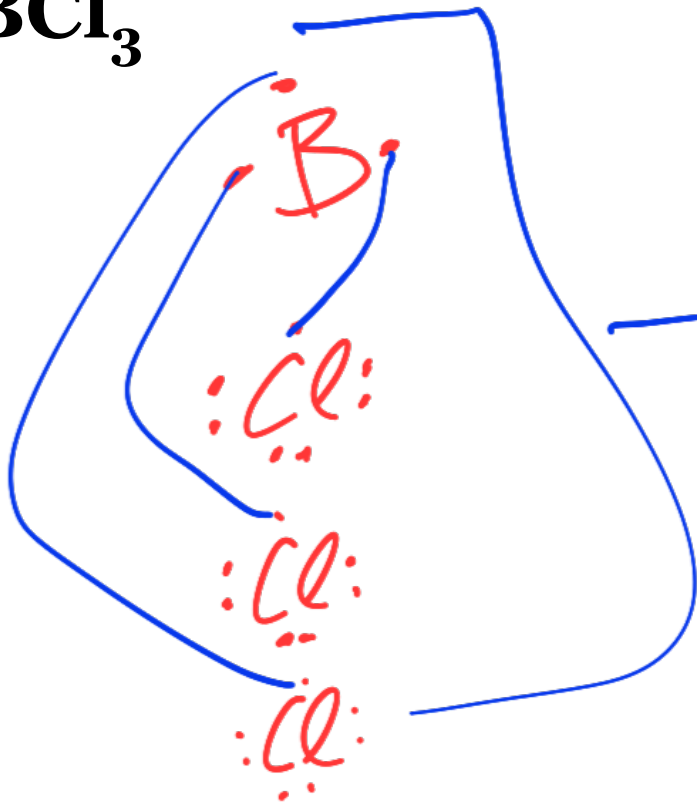
Linear

2 Attachments
(2 bonds)



Linear
2 Attachments (1 bond + 1 lone pair)



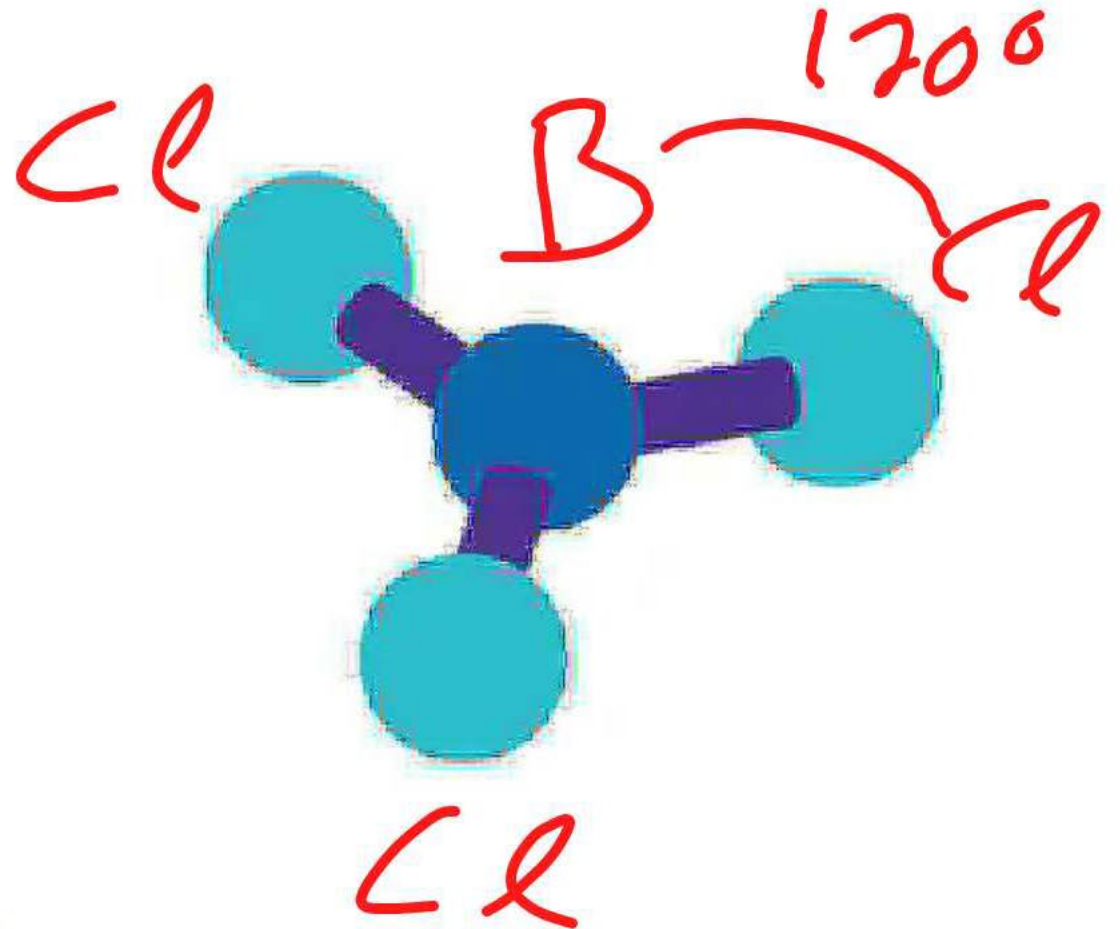


Trigonal Planar

Boron is an exception to the octet rule

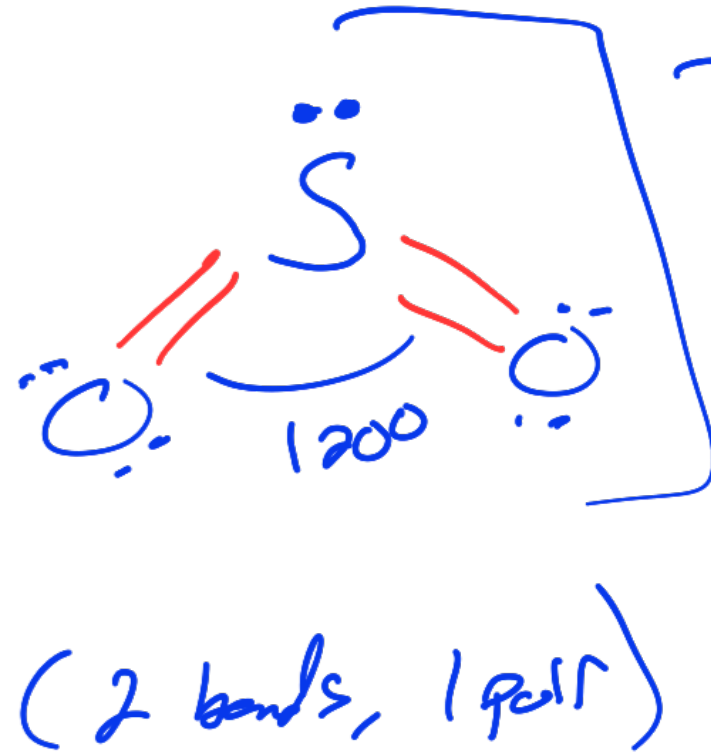
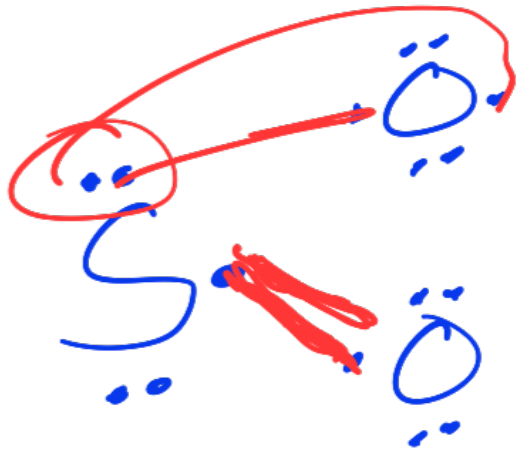
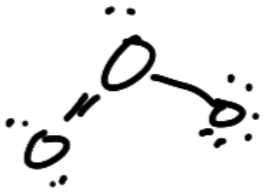


Trigonal
Planar



SO_2

O_3



Trigonal
Planar
↓
V-shaped
Bent

O_2

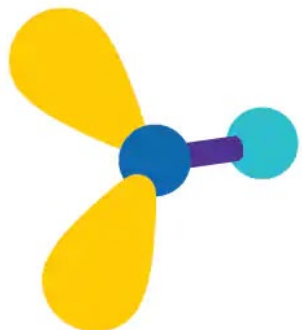


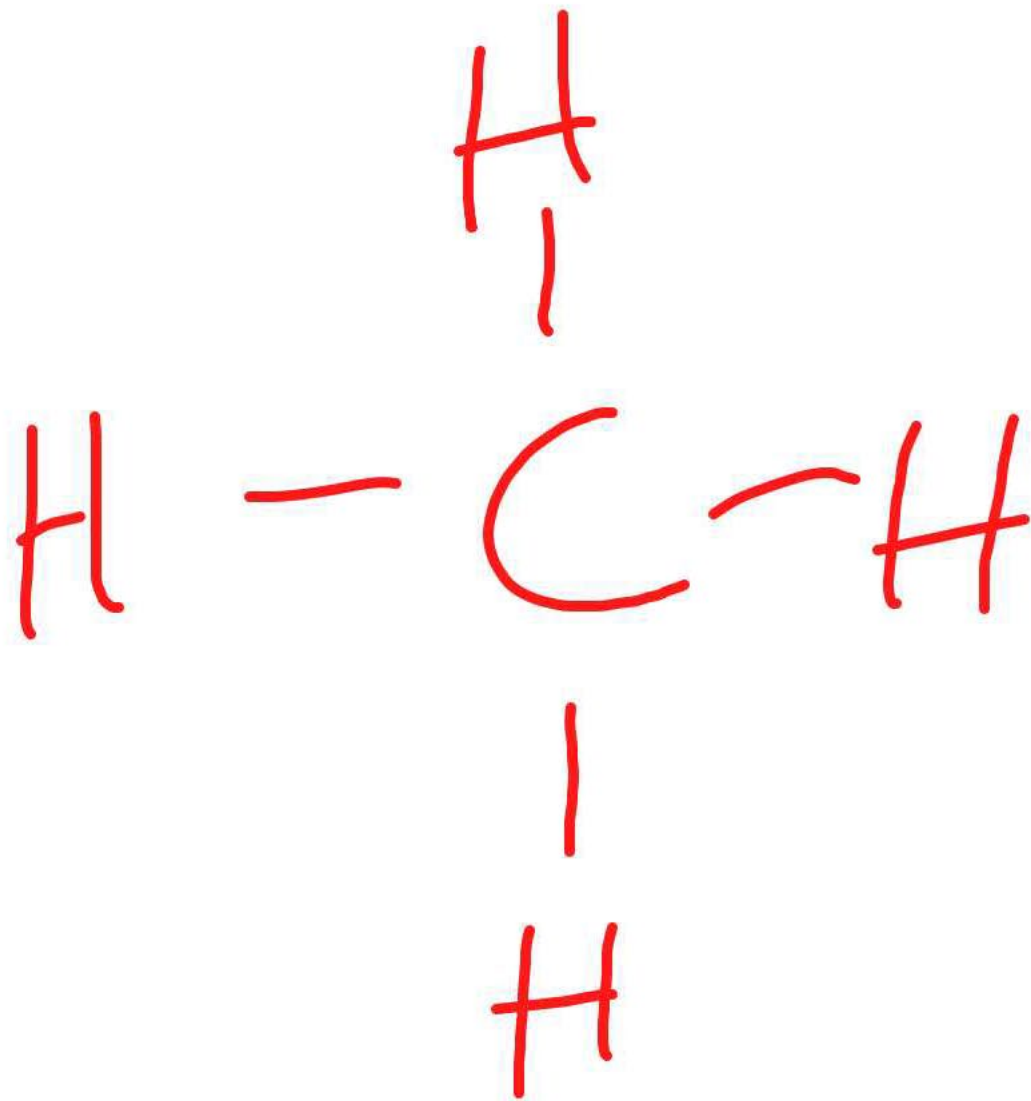
Trigonal Planar
(1 bond, 2 e pairs) } → linear

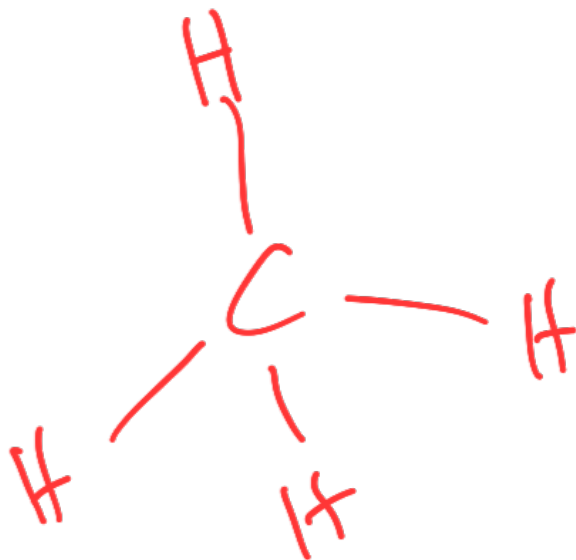
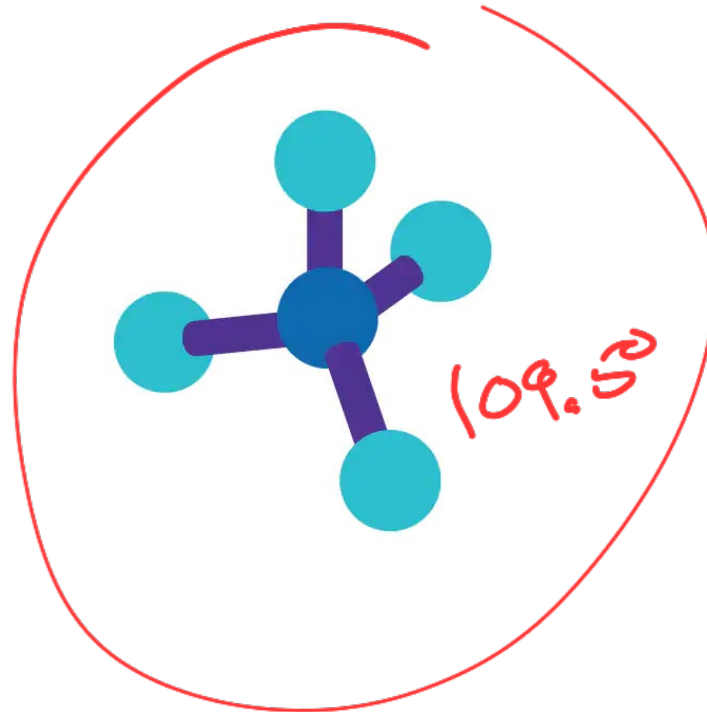
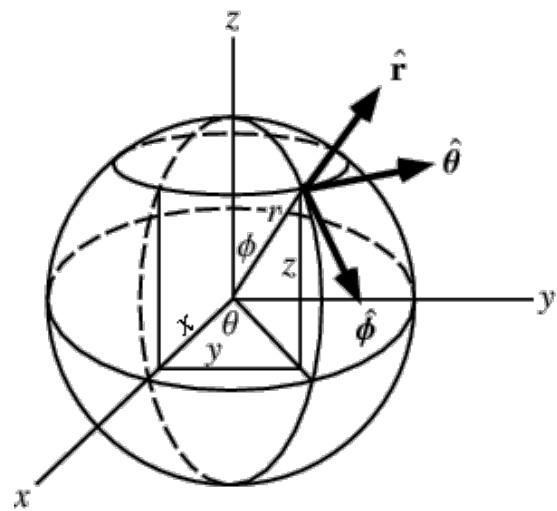
SO₂

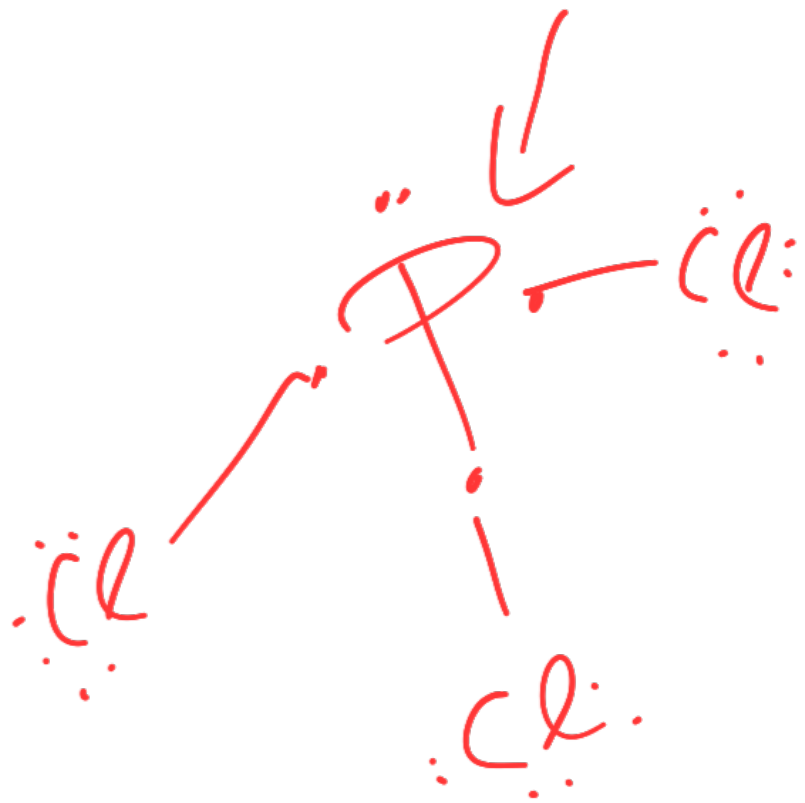


O₂







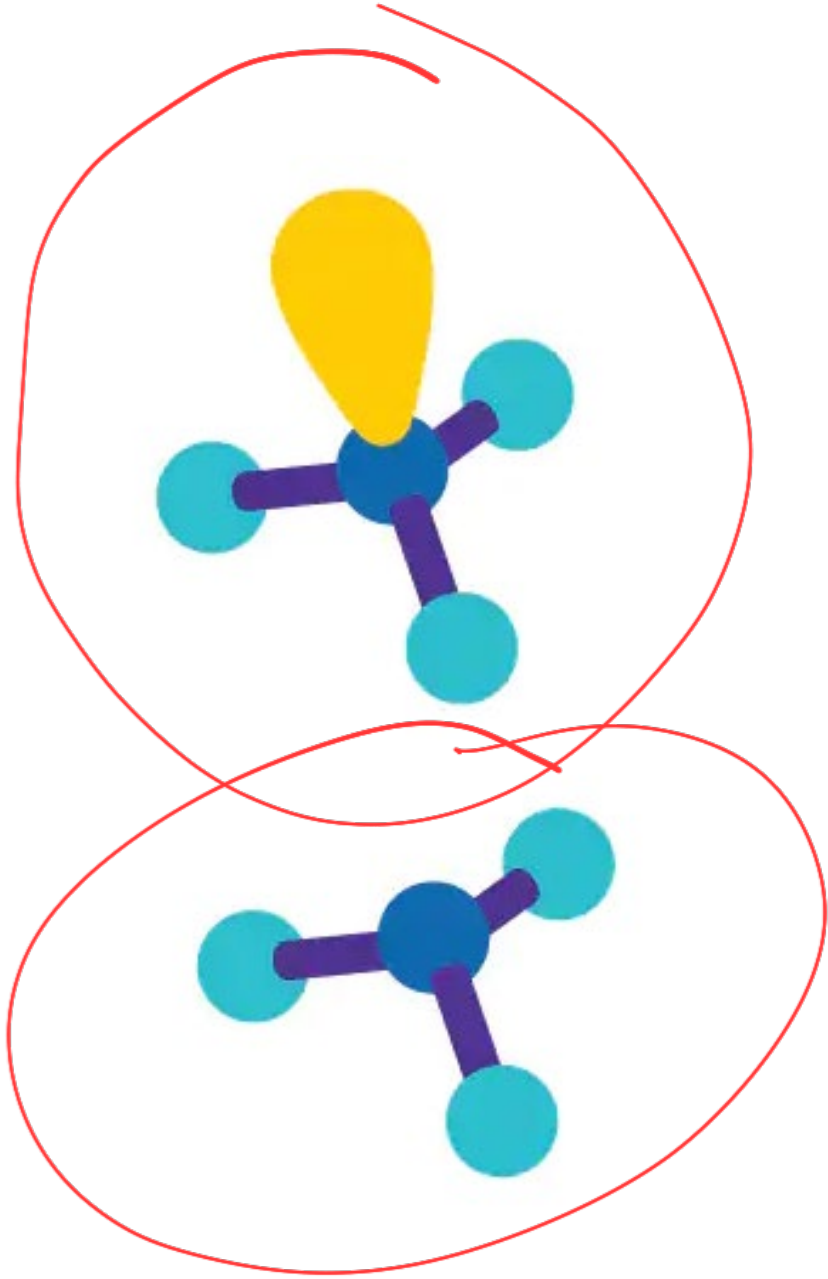


4 attachments

↳ 3 + 1

Trigonal
Pyramidal

PCl₃



H₂O



4 attachments

(2 + 2) Unshaped

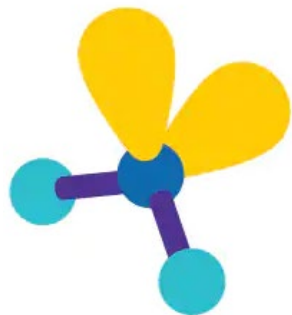
HF



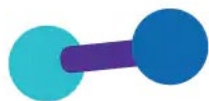
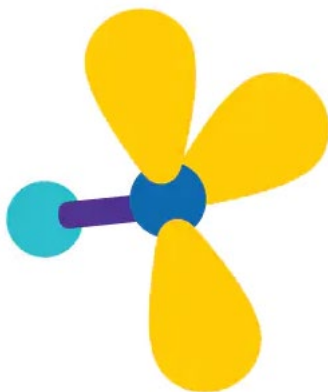
4 attachments

(1 + 3) Linear

H₂O

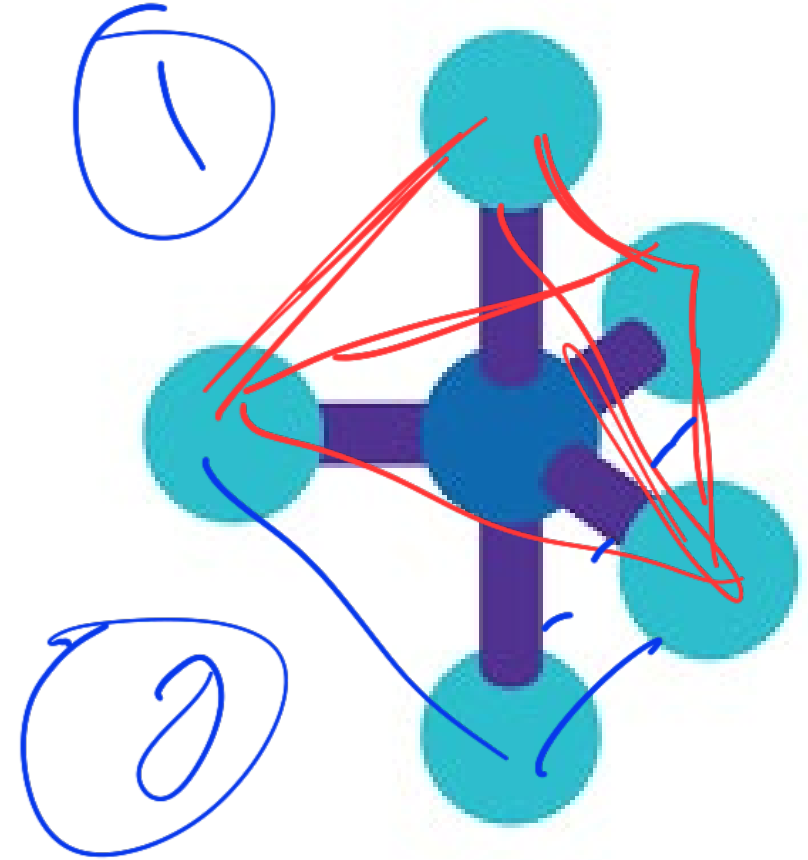


HF

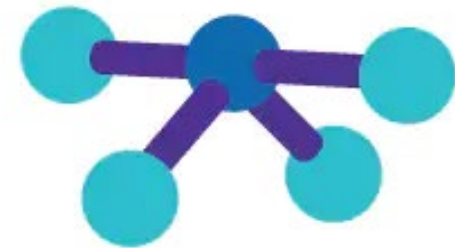


PCl₅

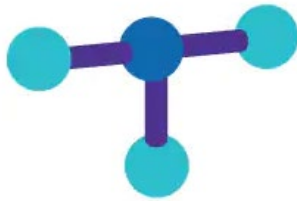
Trigonal
Bipyramidal



SF₄



ClF₃



I₃⁻

