

BERKELEY MATH CIRCLE

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

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Ground Rules

- Octet Rule (except Hydrogen)
- Single Bonds
- Double Bonds
- Triple Bonds
- Lone Pairs

Number of Electrons Drawn

- Obtained from the Periodic Table
- Column's 1-8 = # of e's

Dot Diagrams

- Four sides to our atom symbol
- One dot per side first
- After, electrons can be paired

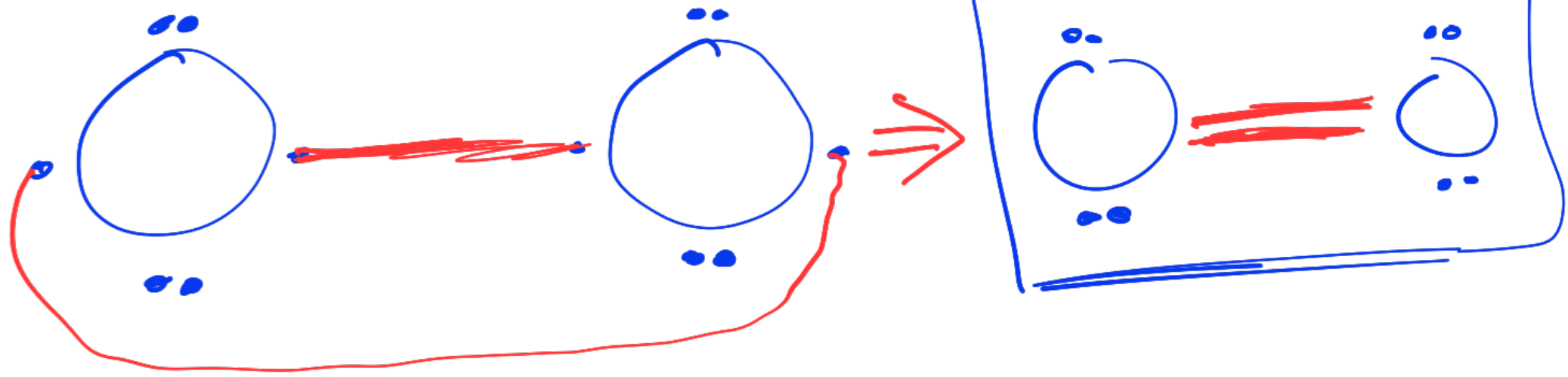
Periodic Table of the Elements

1 IA 11A	2 IIA 2A											3 IIIA 3A	4 IVA 4A	5 VA 5A	6 VIA 6A	7 VIIA 7A	8 VIIIA 8A
1 H Hydrogen 1.008												5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
3 Li Lithium 6.941	4 Be Beryllium 9.012	11 Na Sodium 22.990	12 Mg Magnesium 24.305	13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948								
19 K Potassium 39.098	20 Ca Calcium 40.078	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

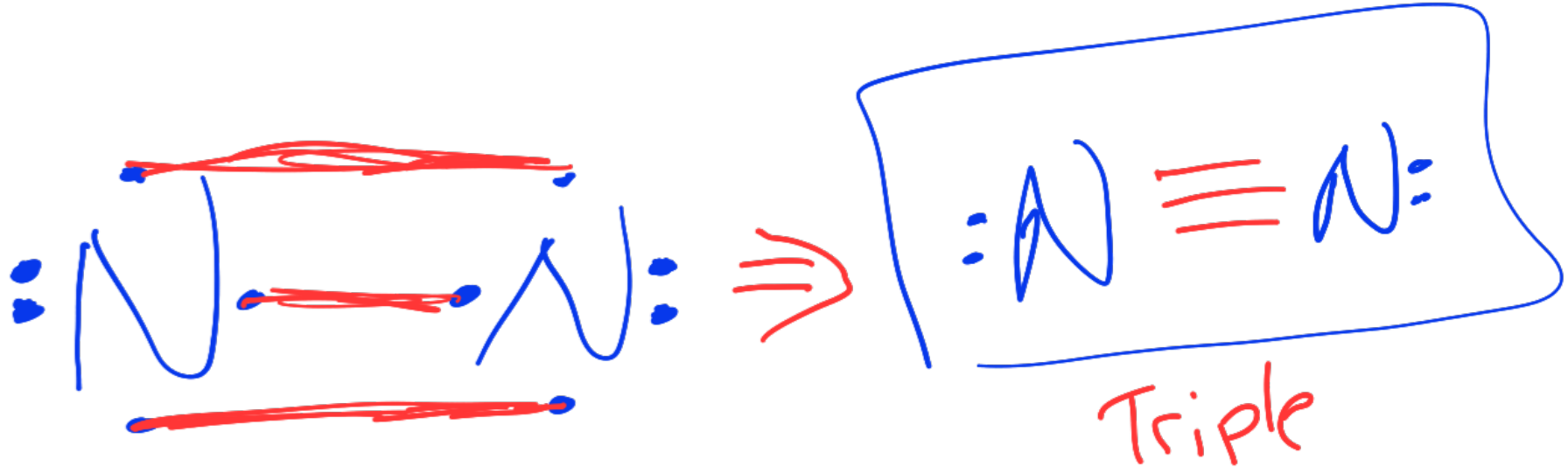


O₂

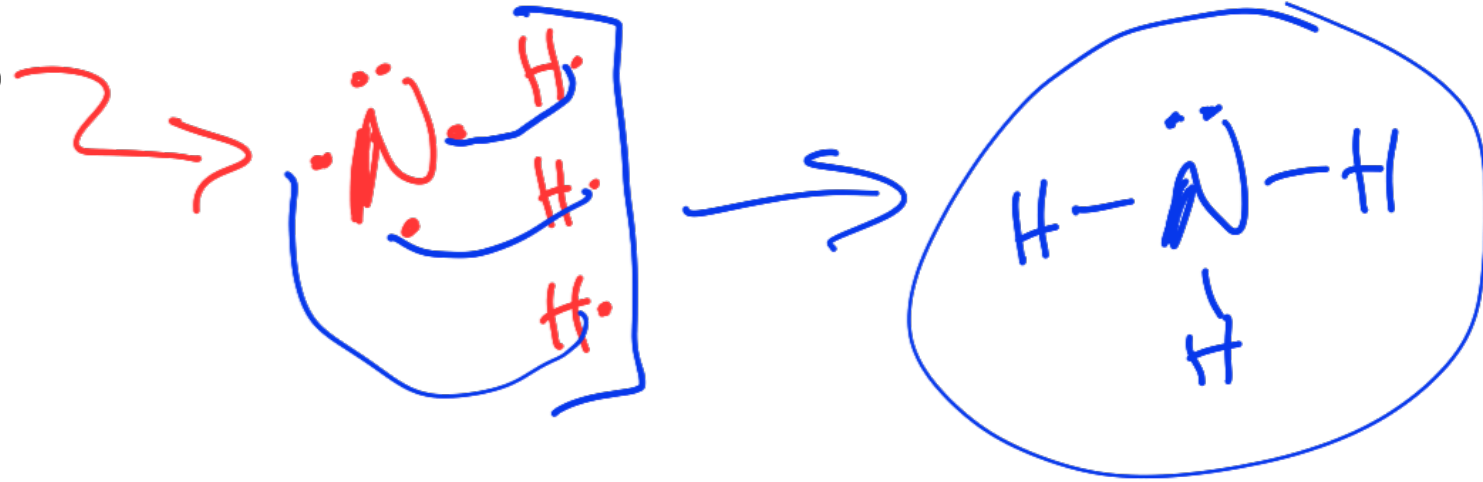
Scratch
↳



N₂



NH₃ (hw)



H₂S (hw)

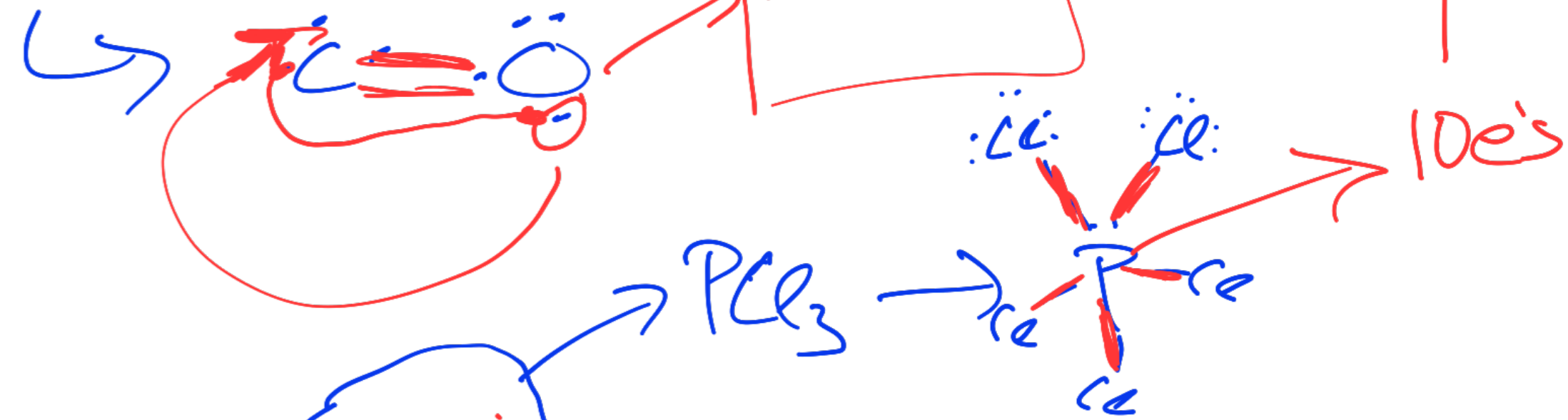


HCN



Let's have fun drawing some EXCEPTIONS (electrons may need to be moved and/ or the Octet rule may be broken!)

CO

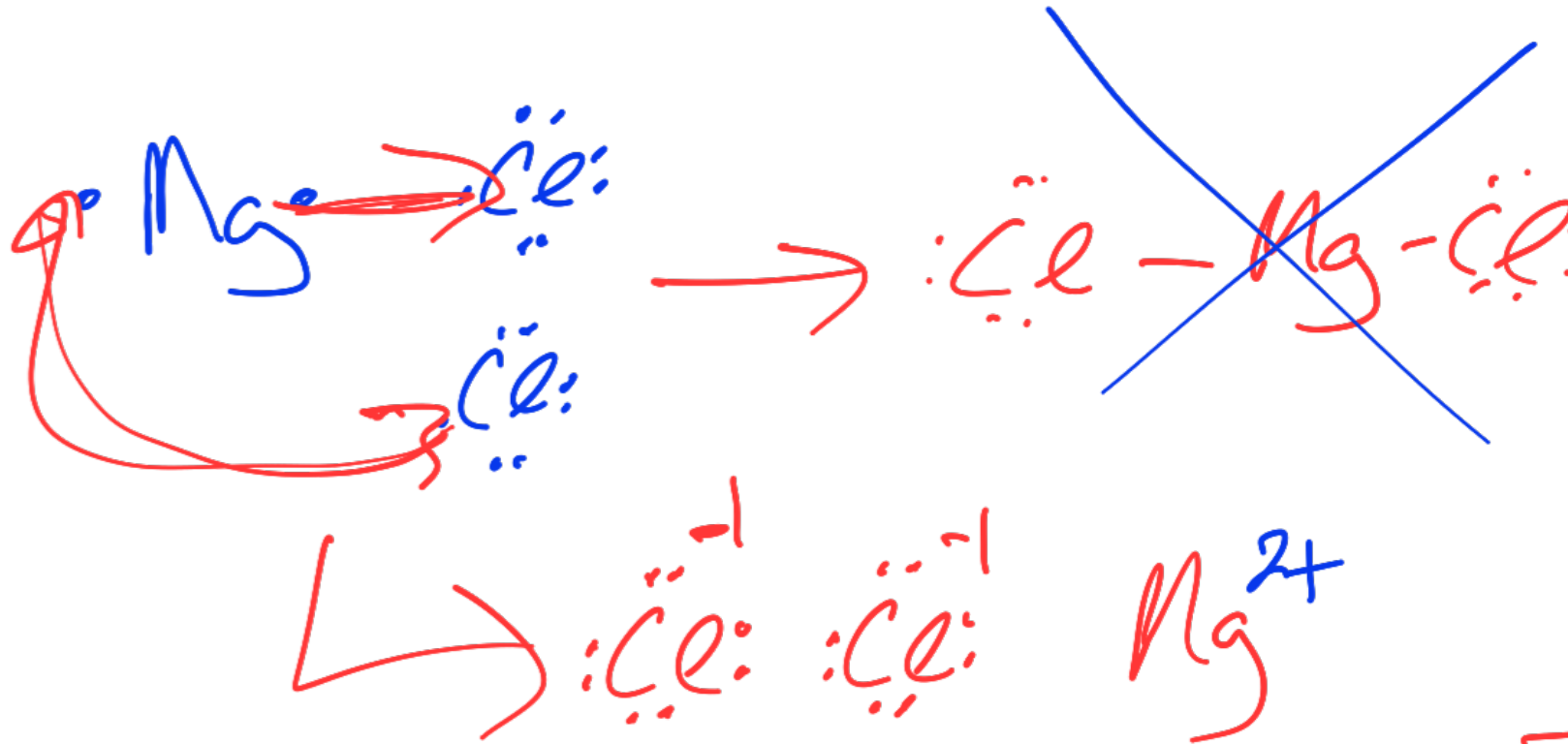


PCl_5 (hw)



Two Bond types in Chemistry

- 1) **Covalent Bonds:** formed from non-metal element with non-metal (sometimes a metalloid with a non-metal). Electrons in these bonds are shared (i.e., what we have been doing – single, double and triple bonds!)
- 2) **Ionic Bonds:** formed from metal with non-metal. In these bond types, electrons are taken or given away. For example:



We have been (and will only) focus on Covalent Bonds (the first type above), as that gets us into VSEPR Theory!

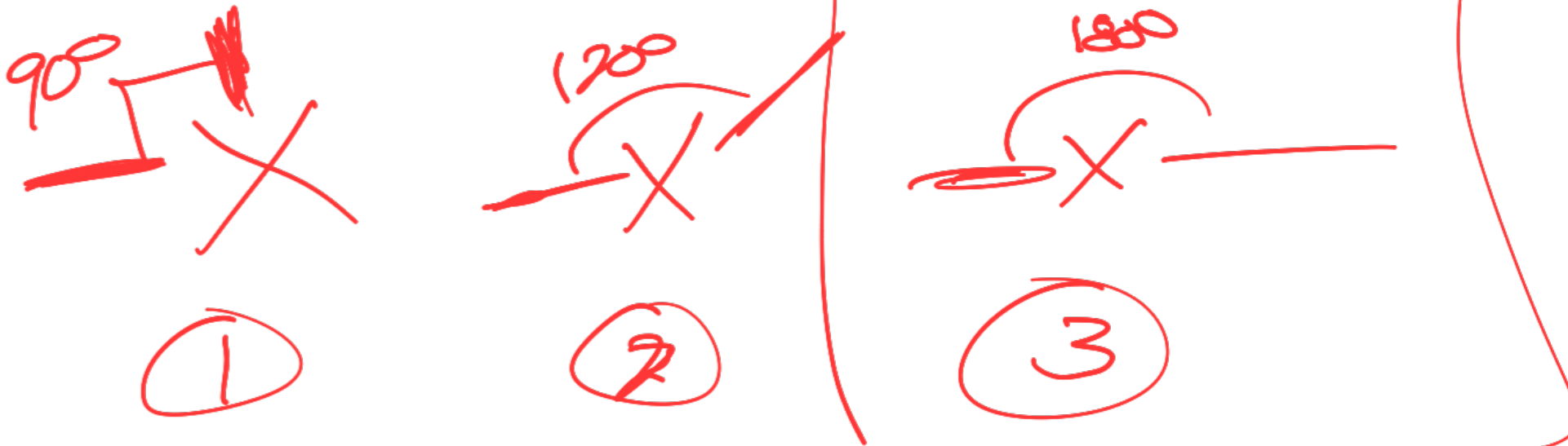
VSEPR Theory

What is VSEPR Theory?

VSEPR Theory = Valence Shell Electron Pair Repulsion Theory

Since electrons REPEL each other, it makes sense that bonds would repel each other since they contain electrons. Similarly, electron pairs, that can be found on atoms, would also repel bonds and other electron pairs.

So, what's the problem? Here some pictorial examples:



All of these bonds and electron pairs are attached to the same central atom! The bonds and electron need to stay attached while simultaneously repelling each other!

This causes them to take on specific shapes. We will use the rest of this lecture to explore those shapes!

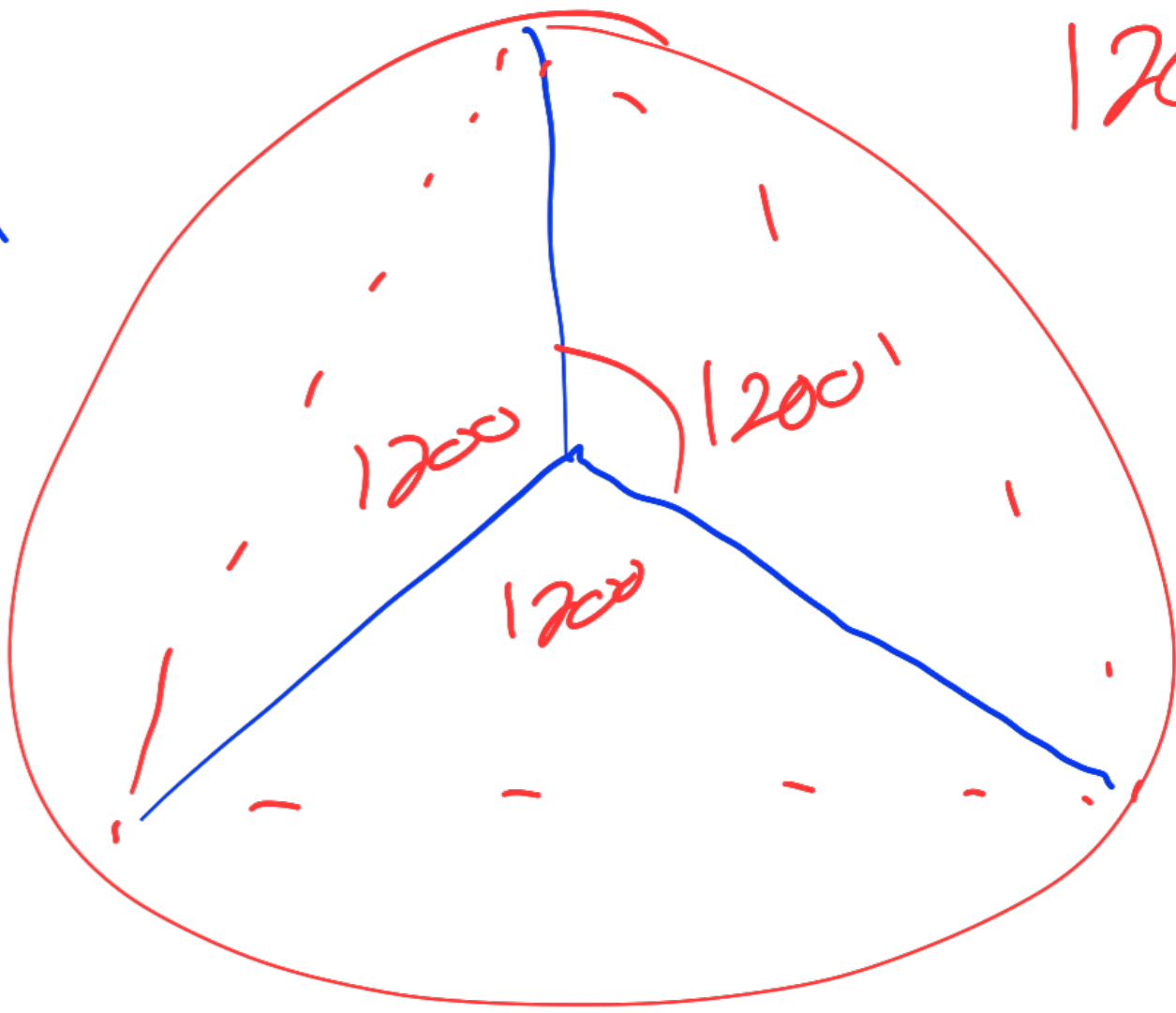
As before, here are some ground rules to use!

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.

Let's look at some of our previous work to start to think about these shapes, and we can even try some new Lewis Structures!

~~Trigonal~~

Trigonal
Planar



120°

$$\frac{360}{3}$$

Reviewed 1, 2, + 3
attachments.

W/ Beg II,
we added
4 attachments