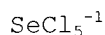


AP CHEMISTRY HANDOUT: BONDING, GEOMETRIES, AND POLARITY

Shortcut method is the preferred method for the number of *blobs* in a *MXE* species when X is any combination of hydrogen or halogen atoms.



- To the group number of the central atom (M), add the number of surrounding atoms (X). Account for the charge of the species and divide by 2 to get the number of "**blobs**".

$$(6+2)/2=8/2=4 \text{ blobs}$$

$$(6+5+1)/2=12/2=6 \text{ blobs}$$

- Each surrounding atom (X) counts as one blob. The rest of the blobs are electron pairs (E).



Consult the table below to determine molecular shape of the species.

- Shapes are obtained from a table and hybridization is determined directly from the number of blobs: 2=sp 3=sp² 4=sp³ 5=sp³d 6=sp³d²

When X is oxygen or another atom besides hydrogen or a halogen, you must find the number of **bonds** in the species and assumes that the species observes **octet rule**.



- Calculate the number of electrons present. Add up group numbers and account for charge of the species.

$$5+4(1)-1=8$$

$$6+4(6)+2=32$$

- Calculate the number of electrons wanted, total. Every atom wants 8 except hydrogen which wants 2.

$$8+4(2)=16$$

$$5(8)=40$$

- Subtract #1 from #2 and divide by 2 to get the number of bonds needed.

$$(16-8)/2=4 \text{ bonds}$$

$$(40-32)/2=4 \text{ bonds}$$

- Draw the skeleton, add multiple bonds and lone pairs. Check the number of atoms, bonds, and total electrons. To determine the shape, count the number of atoms and the number of lone pairs around the central atom, write the *MXE* configuration and consult the table below.

SHAPES

SINGLE BOND
SHARING

UNSHARED ELECTRON PAIR

MX₂: linear

MX₃: trigonal planar

MX₄: tetrahedral

MX₅: triagonal bipyramidal

MX₆: octahedral

MX₂E: bent

MX₃E: pyramidal

MX₄E: unsymmetrical tetrahedron

MX₅E: square pyramid

MX₂E₂: bent

MX₃E₂: T-shaped

MX₄E₂: square planar

MX₂E₃: linear

*NOTE: shapes in bold underlined type are nonpolar if all X atoms are the same.

POLARITY OF NEUTRAL SPECIES

To be polar, a molecule must have polar bonds which **do not cancel**. Polar bonds that cancel result in a nonpolar molecule.

Any molecule which has only 1 type of X surrounding the central atom is likely to be nonpolar because its polar bonds are likely to cancel. Three shapes always cancel if all of their bonds are the same.

Linear

Triangular

Tetrahedral

Combinations of these shapes also cancel. For instance, trigonal bipyramidal cancels because it is a linear and a triangular combination. Square planar and octahedral also cancel since they are composed of 2 sets and 3 sets of linear bonds, respectively. A set composed of 2 different types of bonds such as HCN will not cancel since the bond polarities are not alike. Thus, HCN is polar even though it is a linear shape.

DETERMINE THE SHAPES, HYBRIDIZATION, AND POLARITIES FOR THE FOLLOWING SPECIES:

SPECIES	GEOMETRY	POLARITY	HYBRIDIZATION
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AsF₅

BF₃

SeCl₄

PCl₃

SO₃⁻²

IBr₃

SF₆

IF₅

CO₂

Valence Shell Electron Pair Repulsion Theory

		Structural Pairs	Bonded Pairs (σ)	Lone Pairs	Molecular Geometry	Polarity	Bond angle
Hybridization	sp	2	2	0	Linear	Non-polar	180
		3	3	0	Triangular planar	Non-polar	120
			2	1	Bent	Polar	< 120
	sp^2	4	4	0	Tetrahedral	Non-polar	109.5
			3	1	Triangular pyramidal	Polar	< 109.5
			2	2	Bent	Polar	<< 109.5
5		5	0	Triangular bipyramidal	Non-polar	120 & 90	
		4	1	See-saw	Polar	< 120 & 90	
sp^3		3	2	T-shape	Polar	90	
		2	3	Linear	Non-polar	180	
	sp^3d	6	6	0	Octahedral	Non-polar	90
			5	1	Square pyramidal	Polar	90 & < 90
			4	2	Square planar	Non-polar	90
			3	3	T-shape	Polar	< 90
			2	4	Linear	Non-polar	180