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.

$SeCl_2$ $SeCl_5^{-1}$

1. 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 blobs (6+5+1)/2=12/2=6 blobs

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

   MX_2E_2 MX_5E

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

3. Shapes are obtained from a table and hybridization is determined directly from the number of blobs: 2=sp 3=sp^2 4=sp^3 5=sp^3d 6=sp^3d^2

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.**

NH_4^{+1} SO_4^{-2}

1. 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

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

   8+4(2)=16 5(8)=40

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

   (16-8)/2=4 bonds (40-32)/2=4 bonds

4. 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	
MX_2: linear		
MX_3: trigonal planar	MX_2E: bent	
MX_4: tetrahedral	MX_3E: pyramidal	MX_2E_2: bent
MX_5: triagonal bipyramidal	MX_4E: unsymmetrical tetrahedron	MX_3E_2: T-shaped
MX_6: octahedral	MX_5E: square pyramid	**MX_4E_2: square planar**
		MX_2E_3: 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, triagonal 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
AsF_5			
BF_3			
$SeCl_4$			
PCl_3			
SO_3^{-2}			
IBr_3			
SF_6			
IF_5			
CO_2			

*V*alence *S*hell *E*lectron *P*air *R*epulsion Theory

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