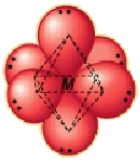
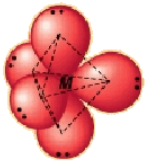
Worksheet 15 - Molecular Shapes

The shapes of molecules can be predicted from their **Lewis structures** by using the **VSEPR** (**V**alence **S**hell **E**lectron **P**air **R**epulsion) model, which states that electron pairs around a central atoms will assume a geometry that keeps them as far apart from each other as possible.

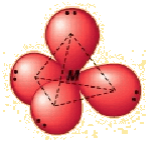
This is illustrated by the drawings below.



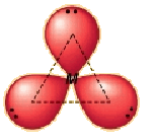
Six groups surrounding a central atom will form an **octahedron**. All of the groups in this structure are at **90^o** or **180^o** to each other. All positions are equivalent



Five groups will form a **trigonal bipyramid**. The two positions pointing up and down are called the **axial** positions. They are at **180^o** to each other, and at **90^o** to the other three, **equatorial** positions. The three **equatorial** positions are at **120^o** to each other. There is more room in the equatorial positions, and large groups will occupy these positions.



Four groups will form a **tetrahedron**. All of the angles in a tetrahedron are **109.5^o**, and all positions are equivalent.



Three groups will form a flat triangle (**trigonal planar**). Each of the angles is **120^o** and all positions are equivalent.

Two groups form a straight line (**linear**) with **180^o** between them.

How does this apply to Chemistry?

The groups occupying these geometric positions will be either **atoms** bonded to the central atom, or **lone pair electrons** on the central atom.

Lone pair electrons occupy **more** space than bonded electrons, so they will take the **equatorial** position in the **trigonal bipyramid**.

Lone pair electrons will also occupy positions that put them as far apart from each other as possible.

1. Draw the Lewis structure for water, H_2O.

a) How many "groups" (atoms and lone pairs) surround the central oxygen?

b) What is the **geometry** of this molecule (look at atoms and lone pairs)? Draw this VSEPR structure next to the Lewis structure.

c) What is the **shape** of this molecule (look only at the atoms)?

d) What is the H-O-H bond angle?

e) Place the partial positive and negative charges on the H and O atoms, based on their relative electronegativities. Is water a **polar** compound?

2. Draw the Lewis structure for NO_2^-.

a) How many "groups" (atoms and lone pairs) surround the central nitrogen?

b) What is the **geometry** of this molecule (look at atoms and lone pairs)? Draw this VSEPR structure next to the Lewis structure.

c) What is the **shape** of this molecule (look only at the atoms)?

d) What is the O-N-O bond angle?

e) Place the partial positive and negative charges on the N and O atoms, based on their relative electronegativities. Is NO_2^- a **polar** compound?

3. Draw the Lewis and VSEPR structures for the following 12 compounds and label them with their **geometry**.

	Lewis	**VSEPR**		**Lewis**	**VSEPR**
a) SF_6			b) ICl_2^-		
c) ICl_4^-			d) SF_4		
e) CF_4			f) BrF_5		
g) BrF_3			h) NH_3		
j) CO_2			k) $XeCl_3^-$		
l) SO_3			m) PF_5		

Now fill in the missing information in the chart using the structures you have drawn in problems 1 - 3.

compound	**atoms** on central atom	**lone pairs** on central atom	**geometry**	**shape**	**polar**
SF_6				octahedral	
	5	1			
	4		octahedral		
$XeCl_3^-$					
	5	0			
	4	1		seesaw	
BrF_3					
			trigonal bipyramidal	linear	
	4	0			
NH_3					
	2	2		V-shaped (bent)	yes
			trigonal planar		no
	2	1			
CO_2					