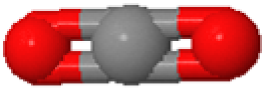
# I9- VSEPR - Multiple Bonds Theory Sheet

***Some molecules have multiple bonds which affect their VSEPR shape. Multiple bonds are bonds such as double bonds and triple bonds which are highly electronegative as they have lots of electrons in their bonds.***



Refcode: *AJABOD*

The VSEPR models of molecules can be found systematically by using the number of electron pairs to determine the shape of the molecules.

To predict the shape of the molecules first draw out the Lewis structure of the molecule. On the Lewis diagram identify the central atom. For this molecule $CO_2$ the central atom is carbon (C).

**TOP TIP!**
If the total number of electrons is an odd number, then that means the calculation has gone wrong. Try the calculation again.


To work out how many electrons are in the outer shell of the central atom carbon, just look at what group it is in and the group number as this is the same as the number of electrons on the outer shell of the central atom. Carbon is in group 4 so it has 4 electrons in its outer shell. Each atom that is bonded to the central atom will contribute electrons to it; add the extra electrons to the number of valence shells (one per bond i.e. 2 per double bond). For the $CO_2$ molecule there are 2 oxygen atoms which contribute 2 electrons each, so adding the 4 electrons to the valance shells totals 8 electrons. The carbon has no charge, so no extra electrons are needed so the final total is 8. Divide the total number of electrons by 2, for $CO_2$ the number is 4, and this should give the total number of electron pairs. The initial VSEPR shape for the $CO_2$ molecule is Tetrahedral. For each multiple bond (double/triple bond), subtract one electron from the final total. The $CO_2$ molecule has 2 double bonds so minus 2 electrons from the final total. So the overall total number of electrons should be 2, this is the electron region number. Using the table in the next section and the electron region number, find the VSEPR model which is assigned to the molecule.

| **[$CO_2$] To Summarise:** | |
|---|---|
| Central Atom | Carbon |
| Valence Electrons on Central Atom | 4 |
| 2 [O] atoms (contributing 2 electron each) | 4 |
| No charge on [C] | 0 |
| Total | 8 |
| Divide by 2 (number of electron pairs) | 4 (initial VSEPR shape is *tetrahedral*) |
| -1 electron pair for each double bond | -2 electrons (2) |
| Overall total | 2 |
| 2 electron regions | **Linear** (VSEPR model for 2 electron pairs) |

Check if the VSEPR model of the molecule is correct by going to the database and examining the crystal structure (the refcode for the [$CO_2$] molecule is *AJABOD*). Measure the bond angles on the molecule comparing them to the ideal VSEPR model angles in the table in the next section. Measure the bond angles on the $CO_2$ molecule and compare them to the ideal bond angles on a linear molecule.

**TOP TIP!**
If the central atom is positive, then minus 1 electron from the overall electron total; if the central atom is negative, then add 1 electron to the overall electron total.


**TOP TIP!**
If it is an oxy ion, (central atom bonded to the oxygen) the negative charge is on the oxygen not the central atom. shouldn't be counted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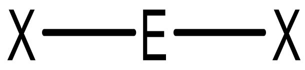
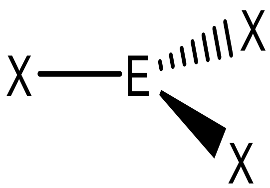
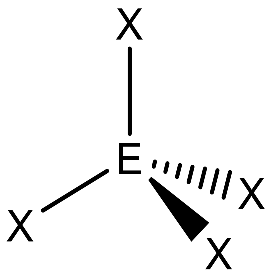
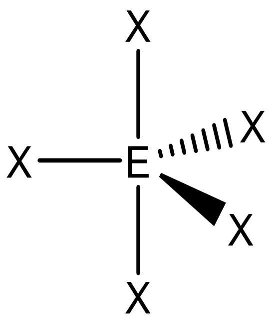
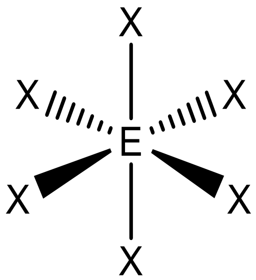
# Ig- VSEPR - Multiple Bonds Theory Sheet

| Formula ($EX_n$) | Number of Electron Pairs | Shape | Spatial Arrangement | Theoretical Bond Angle |
|---|---|---|---|---|
| $EX_2$ | 2 | Linear |  | $180^o$ |
| $EX_3$ | 3 | Trigonal Planar |  | $120^o$ |
| $EX_4$ | 4 | Tetrahedral |  | $109.5^o$ |
| $EX_5$ | 5 | Trigonal Bi-pyramidal |  | Axial-Equatorial $90^o$<br>Axial-Axial $120^0$ |
| $EX_6$ | 6 | Octahedral |  | $90^0$ |