Section 6-5 Molecular Geometry (VSEPR Theory)

Molecular Polarity

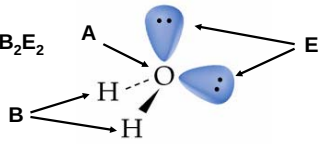
The uneven distribution of molecular charge. This is determined by polarity of each bind and the geometry of the molecule.

VSEPR Theory (Valence Shell Electron Pair Repulsion)

states that repulsion between the sets of valence level electrons surrounding an atom causes these sets to be oriented as fart apart as possible

The central atom is referred to as A. Each bonded atom is referred to as B. Each lone pair is referred to as E. A central atom having two bonded atoms and two lone pairs would be called AB_2E_2.

Water is AB_2E_2



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Balloon Analogy Shows the Repulsion of Electron Pairs.

Linear

Trigonal Planar

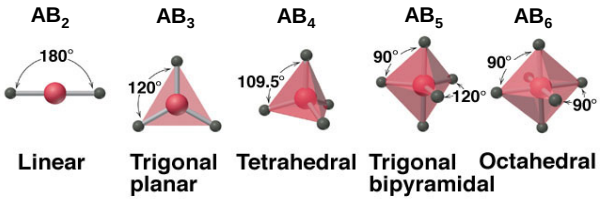
Tetrahedral

Trigonal Bipyramidal

Octahedral

2

Electron-Group Repulsions and the Five Basic Molecular Shapes



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Number of Bonds	Number of Lone Pairs	Number of Charge Clouds	Molecular Geometry	Example
2	0	2	Linear 180°	O=C=O
3	0	3	Trigonal planar 120°	H–C(=O)–H
2	1		Bent 120°	O–S–O
4	0	4	Tetrahedral 109.5°	CH4
3	1		Trigonal pyramidal 107.5°	NH3
2	2		Bent 105°	H2O

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Number of Bonds	Number of Lone Pairs	Number of Charge Clouds	Molecular Geometry	Example
5	0	5	Trigonal bipyramidal 120° & 90°	PCl5
4	1		Seesaw 120° & 90°	SF4
3	2		T-shaped 90°	ClF3
2	3		Linear 180°	I3−

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Number of Bonds	Number of Lone Pairs	Number of Charge Clouds	Molecular Geometry	Example
6	0	6	Octahedral 90°	SF6
5	1		Square pyramidal 90°	SbCl5 2−
4	2		Square planar 90°	XeF4

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TABLE 6-5 VSEPR and Molecular Geometry

	Molecular shape	Atoms bonded to central atom	Lone pairs of electrons	Type of molecule	Formula example	Lewis structure
Linear		2	0	AB_2	BeF_2	
Bent or angular		2	1	AB_2E	$SnCl_2$	
Trigonal-planar		3	0	AB_3	BF_3	
Tetrahedral		4	0	AB_4	CH_4	
Trigonal-pyramidal		3	1	AB_3E	NH_3	
Bent or angular		2	2	AB_2E_2	H_2O	
Trigonal-bipyramidal		5	0	AB_5	PCl_5	
Octahedral		6	0	AB_6	SF_6	

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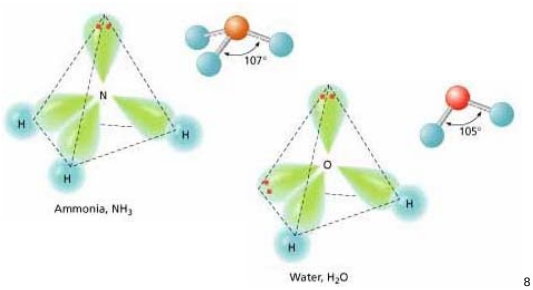
Unshared Electron Pairs

Unshared electron pairs repel electrons stronger than bonding electron pairs. This will cause the bond angles in H_2O and NH_3 to be less than 109.5°.



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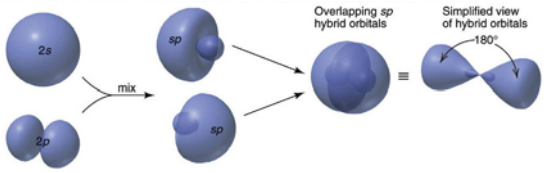
Hybridization

Hybridization

The mixing of two or more atomic orbitals of similar energies on the same atom to produce new orbitals of equal energies

Hybrid Orbitals

Orbitals of equal energy produced by the combination of two or more orbitals on the same atom



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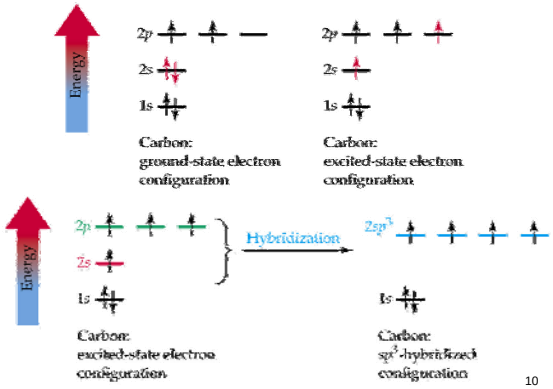
Hybridization of Orbitals



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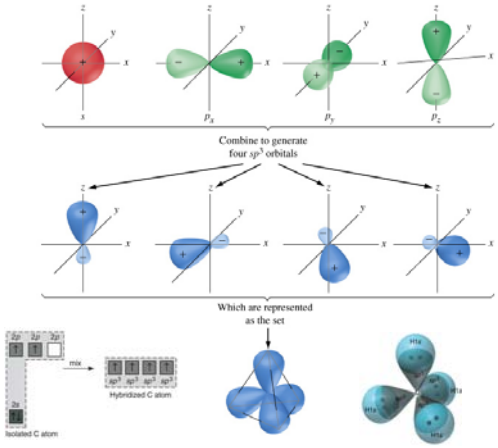

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TABLE 6-6 Geometry of Hybrid Orbitals

Atomic orbitals	Type of hybridization	Number of hybrid orbitals	Geometry
s, *p*	*sp*	2	180° Linear
s, *p*, *p*	sp^2	3	120° Trigonal-planar
s, *p*, *p*, *p*	sp^3	4	109.5° Tetrahedral

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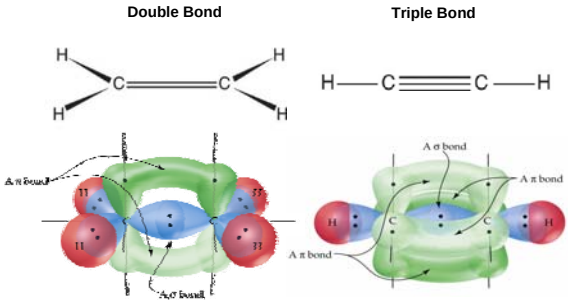
What Double Bonds and Triple Bonds Look Like



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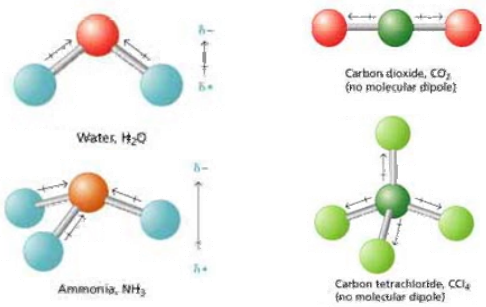
Molecular Polarity

Dipole $\delta^+ \longrightarrow \delta^-$

Equal but opposite charges that are separated by a short distance (δ^+ for positive end and δ^- for negative end)



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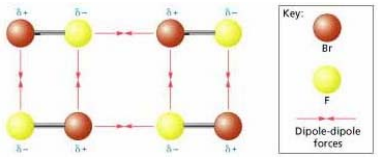
Intermolecular Forces

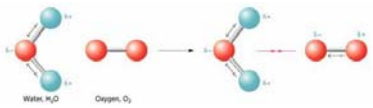
Dipole-Dipole Forces

The forces of attraction between polar molecules



Induced Dipole Forces

Weak forces of attraction from a polar molecule attracting electrons from a nonpolar molecule to create a temporary dipole



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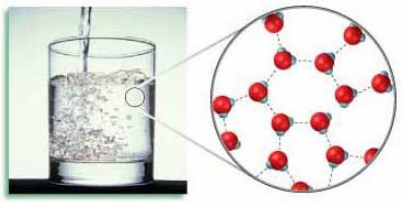
Intermolecular Forces

Hydrogen Bonding

Intermolecular force in which a hydrogen atom that is bonded to a highly electronegative atom is attracted to an unshared pair of electrons of an electronegative atom in a nearby molecule

Hydrogen bonding is a strong type of dipole-dipole force that gives H_2O, NH_3, and HF higher than expected boiling points.



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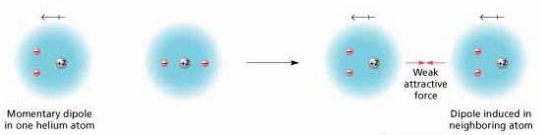
Intermolecular Forces

London Dispersion Forces

Intermolecular attractions resulting from the constant motion of electrons and the creation of instantaneous dipoles

All atoms and molecules will have some effect from London Forces.

London Forces are the only intermolecular forces that act on noble gas atoms and nonpolar molecules.



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Comparison of Bond Types

TABLE 6-7 *Boiling Points and Bonding Types*

Bonding type	Substance	bp (1 atm, °C)	
Nonpolar-covalent (molecular)	H_2	−253	Weak
	O_2	−183	
	Cl_2	−34	
	Br_2	59	
	CH_4	−164	
	CCl_4	77	
	C_6H_6	80	
Polar-covalent (molecular)	PH_3	−88	
	NH_3	−33	
	H_2S	−61	
	H_2O	100	
	HF	20	
	HCl	−85	
	ICl	9 7	
Ionic	NaCl	1413	Strong
	MgF_2	2239	
Metallic	Cu	2567	
	Fe	2750	
	W	5660	

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