VC210

Final Review

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Units

- Common units: Pound, Inch, Minute...
- **SI Units**: Kilogram (kg), Second (s), Kelvin (K)
- SI Prefixes:
  - mega-(M): 10^6
  - kilo-(k): 10^3
  - milli-(m): 10^{-3}
  - micro-(μ): 10^{-6}
  - nano-(n): 10^{-9}

Significant Figures

- Addition and Subtraction: Round off the result to the leftmost decimal place.

$$40.123 + 20.34 = 60.46$$

- Multiplication and Division: Round off the result to the smallest number of significant figures.

$$1.23 \times 2.0 = 2.5$$

- Logarithms: retain in the mantissa the same number of SF as there are in the number whose logarithm you are taking.

$$\log 12.8 = 1.107$$

- Exponents: The number of SF is the same as in the mantissa.

$$10^{1.23} = 17$$

Nuclear Model of the Atom

- $e = 1.602 \times 10^{-19} C$
- $m_e = 9.109 \times 10^{-31} kg$
- Rutherford's model of atom: All the positive charge and almost all the mass is concentrated in the tiny nucleus, and the negatively charged electrons surround the nucleus.

Electromagnetic Radiation

- Speed of light: $c = 3 \times 10^8 m \cdot s^{-1}$
- $1Hz = 1s^{-1}$
- $\lambda \times v = c$

Some Important Formula

- $v = R(\frac{1}{n_1^2} - \frac{1}{n_2^2})$
- Rydberg constant: $R = 3.29 \times 10^{15} Hz$
- Wave-Particle Duality of Matter: $E = hv = \frac{hc}{\lambda}$
- de Broglie Relation: $E = pc$(p is momentum)
- A Particle in the Box: $E_n = \frac{n^2 h^2}{8mL^2}$

Quantum Numbers

- Principal quantum number n(shell)
- Orbital angular momentum quantum number $l \in [0, n-1]$(subshell)
  - $l = 0(s)$, $l = 1(p)$, $l = 2(d)$...
- Magnetic quantum number $m_l \in [-l, l]$(orbitals)
- Spin magnetic quantum number $m_s \in \{\frac{1}{2}, -\frac{1}{2}\}$

Atomic Orbitals

- Nodes: $n - 1$
- Radial(spherical) nodes: $n - l - 1$
- Angular(planer) nodes: l

The Building-Up Principle

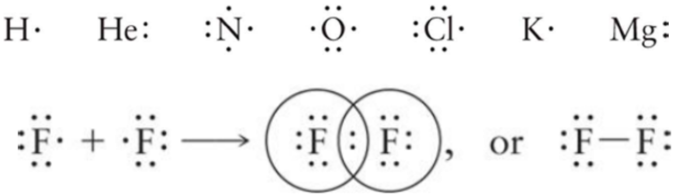
- Pauli Exclusive Principle: no two electrons in one atom have the same four quantum number.
- Lowest Energy Principle: electrons tend to enter orbitals with lower energy first.
  - Energy ranking: $1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s < ...$
- Hund's Rule: For degenerate orbitals, the lowest energy is attained when the number of electrons having same spin is maximized.
- Hund's exception: For same subshell, when electrons are full or half-full or empty, it is most stable.(Cu)

Periodicity

- Atomic Radius:
  - Same row: radius decreases from left to right.
  - Same column: radius increase from up to down.
- Ionization Energy: minimum energy needed to remove an electron from an neutral gas phase atom. Mostly increases from the lower left corner to upper right corner.
- Electron Affinity: Energy released when an electron is added to gas phase atom. Mostly increases from the lower left corner to upper right corner.

Lewis Symbols

- Three bond types: metal bond, ionic bond, covalent bond.
- For Lewis symbols: a single dot represents a valence electron, double dots represent a lone pair of electrons, one line represents a bond (pair electrons).



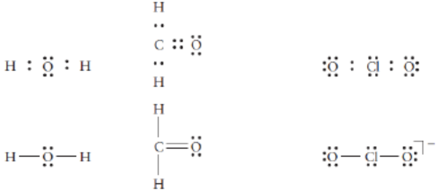
Draw Linkage for Polyatomic Molecules

SOLVE

	(a) H_2O	(b) H_2CO	(c) ClO_2^-
Step 1 Count the valence electrons and adjust the number for charges on ions.	1 + 1 + 6 = 8	1 + 1 + 4 + 6 = 12	7 + 6 + 6 + 1 = 20
Count the electron pairs.	4	6	10
Step 2 Arrange the atoms.	H O H	H / C O / H	O Cl O
Step 3 Place one electron pair between each pair of bonded atoms.	H : O : H	H : C : O : H	O : Cl : O
Step 4 Count electron pairs not yet located.	:: (2)	::: (3)	:::::::: (8)

Complete the octets with lone pairs. If there are not enough electrons to give each atom an octet or duplet with single bonds, use multiple bonds.

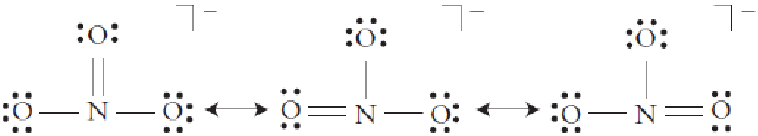
Step 5 Represent the bonds by lines and indicate charges.



Resonance

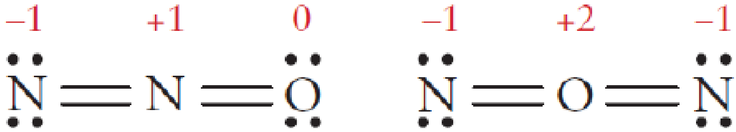
- Keep relative position of atoms.
- Only change electron configuration.
- All atoms in resonance should be coplanar.
- Number of paired and unpaired electrons keep unchanged.
- Bond Order:

$$\frac{\textit{Number of bonds at the same positions in all its resonance structures}}{\textit{number of resonance structures}}$$



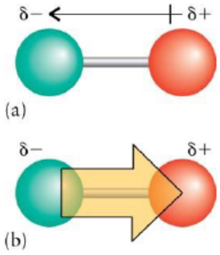
Formal Charge

- $Formal\ Charge = V - (L + \frac{1}{2}B)$
  - V: number of valence electrons
  - L: number of lone-pair electrons
  - B: number of bonding electrons
- Formal charges closest to zero represents the lowest energy arrangement of the atoms.



Electric Dipole Moment

- Elements with higher electronegativity values are considered as negative poles. With larger differences in electronegativity, the dipole moment is larger.
- There are two different drawings.



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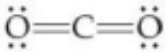
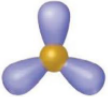
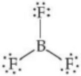
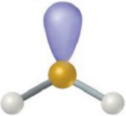
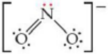
	1	2	13/III	14/IV	15/V	16/VI	17/VII	18/VIII
				H 2.2				He
2	Li 1.0	Be 1.6	B 2.0	C 2.6	N 3.0	O 3.4	F 4.0	Ne
3	Na 0.93	Mg 1.3	Al 1.6	Si 1.9	P 2.2	S 2.6	Cl 3.2	Ar
4	K 0.82	Ca 1.3	Ga 1.6	Ge 2.0	As 2.2	Se 2.6	Br 3.0	Kr
5	Rb 0.82	Sr 0.95	In 1.8	Sn 2.0	Sb 2.1	Te 2.1	I 2.7	Xe
6	Cs 0.79	Ba 0.89	Tl 2.0	Pb 2.3	Bi 2.0	Po 2.0	At	Rn

VSEPR

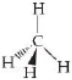
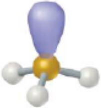
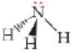
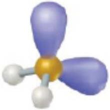
To find geometry:

- Draw the lewis structure.
- Find AX_nE_m.
  - A: central atom
  - X: number of bonds
  - E: number of lone pairs
- Search the table and find.

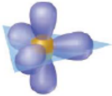
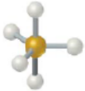
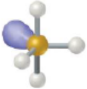
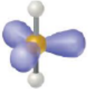
VSEPR

Number of Electron Domains	Electron-Domain Geometry	Bonding Domains	Nonbonding Domains	Molecular Geometry	Example
2	 Linear	2	0	 Linear	
3	 Trigonal planar	3	0	 Trigonal planar	
		2	1	 Bent	

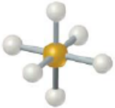
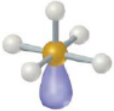
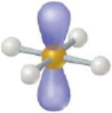
VSEPR

Number of Electron Domains	Electron-Domain Geometry	Bonding Domains	Nonbonding Domains	Molecular Geometry	Example
4	 Tetrahedral	4	0	 Tetrahedral	
		3	1	 Trigonal pyramidal	
		2	2	 Bent	

VSEPR

Number of Electron Domains	Electron-Domain Geometry	Bonding Domains	Nonbonding Domains	Molecular Geometry	Example
5	 Trigonal bipyramidal	5	0	 Trigonal bipyramidal	PCl_5
		4	1	 Seesaw	SF_4
		3	2	 T-shaped	ClF_3
		2	3	 Linear	XeF_2

VSEPR

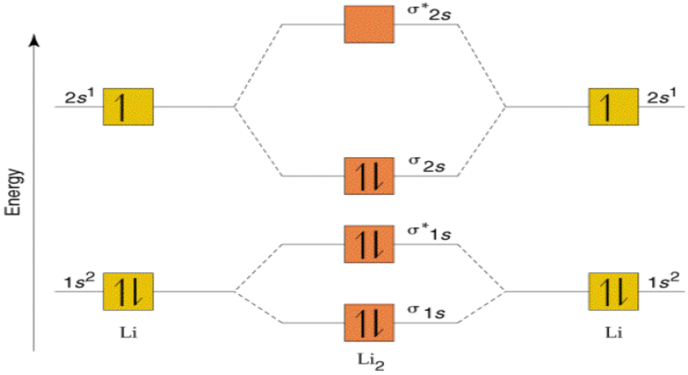
Number of Electron Domains	Electron-Domain Geometry	Bonding Domains	Nonbonding Domains	Molecular Geometry	Example
6	 Octahedral	6	0	 Octahedral	SF_6
		5	1	 Square pyramidal	BrF_5
		4	2	 Square planar	XeF_4

Valence Bond Theory

- σ-bond and π-bond: single bond is a σ-bond, double bond is a σ-bond plus a π-bond, triple bond is a σ-bond plus two π-bonds.
- Hybridization: $k = m + n$, m is the number of lone pairs of central atom, n is the number of atoms connected to central atom.
  - $sp : k = 2$
  - $sp^2 : k = 3$
  - $sp^3 : k = 4$
  - $sp^3d : k = 5$
  - $sp^3d^2 : k = 6$

Molecular Orbital Theory

- The number of MOs equals the number of AOs.
- The MO can be classified as bonding, nonbonding and antibonding.
- $E(\sigma_{1s}) < E(\sigma^*_{1s})$
- The number of electrons is unchanged.



Molecular Orbital Theory

- Be sure to remember the order of the following MO diagram.
- More electronegative element has lower energy.
- Bond Order: $\frac{1}{2}(N_{bonding} - N_{antibonding})$
- Paramagnetic: has unpaired electrons.
- Diamagnetic: all electrons are paired.

Large 2*s*-2*p* interaction				Small 2*s*-2*p* interaction			
	B_2	C_2	N_2		O_2	F_2	Ne_2
σ^*_{2p}				σ^*_{2p}			↑↓
π^*_{2p}				π^*_{2p}	↑ ↑	↑↓ ↑↓	↑↓ ↑↓
σ_{2p}			↑↓	π_{2p}	↑↓ ↑↓	↑↓ ↑↓	↑↓ ↑↓
π_{2p}	↑ ↑	↑↓ ↑↓	↑↓ ↑↓	σ_{2p}	↑↓	↑↓	↑↓
σ^*_{2s}	↑↓	↑↓	↑↓	σ^*_{2s}	↑↓	↑↓	↑↓
σ_{2s}	↑↓	↑↓	↑↓	σ_{2s}	↑↓	↑↓	↑↓

Good Luck!