

1 Morning class week 4 days 4 and 5: Lewis structures and VSEPR

- In answering the following questions, please assume the octet rule is always obeyed. *Remember that in traditional Lewis structures only the second main group elements C, N, O, F, and Ne systematically obey the octet rule.*
 - How many bonds does a neutral carbon atom have in a stable compound?
 - How many bonds does a neutral fluorine atom have in a stable compound?
 - How many bonds does a Si^{-2} atom have in a stable compound?
 - How many bonds does a neutral Bi atom have in a stable compound?
 - How many bonds does an O^{-} atom have in a stable compound?
 - How many bonds does a N^{+} have in a stable compound?
 - How many bonds does a Xe^{2+} have in a stable compound?
 - How many bonds does a neutral tellurium atom have in a stable compound?
 - How many bonds does a neutral iodine atom have in a stable compound?
 - How many bonds does a I^{-} have in a stable compound?
 - How many bonds does a neutral germanium atom have in a stable compound?
- Please draw **Lewis structures** for all the molecules below. Please add all lone pairs to all your Lewis structures. For these systems, the traditional and modern Lewis structures are identical.
 - H_2O , water.
 - NH_3 , ammonia.
 - HOCl , bleach.
 - steam.
 - CH_4 , methane.
 - C_2H_6 , ethane. Assume all carbon atoms are chemically equivalent, ie., have the same chemical environment, and all hydrogen atoms are chemically equivalent.
 - SCl_2
 - S_6 , assume all sulfur atoms are chemically equivalent.
- Please draw **Lewis structures** for all the molecules below. Please add all lone pairs to all your Lewis structures. Many of the molecules in this set form multiple bonds. *Stable main group multiple bonds have, on at least one side of the bond, a second row element.* For these systems, the traditional and modern Lewis structures are identical.
 - C_2H_4 , ethylene.
 - CH_3NHCH_3
 - C_2OH_4 , there are three stable molecules which can be drawn for this stoichiometry.

- (d) C_6H_6 , benzene. All carbon atoms and also all hydrogen atoms are chemically equivalent.
- (e) P_4 , white phosphorus. All P atoms are chemically equivalent.
- (f) N_2
- (g) F_2
- (h) O_2
4. Explain why S_2 is not a stable molecule under ordinary conditions.
5. While second row main group elements C, N, O, F, and Ne almost always obey the octet rule, in traditional Lewis structures, other main group atoms sometimes do not. Please draw **traditional Lewis structures** for all the molecules below. Please add all lone pairs to all the Lewis structures you draw.
- (a) $POCl_3$
- (b) SO_4^{2-} , the sulfate ion.
- (c) SO_2Cl_2
- (d) PO_4^{3-} , the phosphate ion.
- (e) $P_2O_7^{4-}$
- (f) S_2F_2
- (g) I_3^-
- (h) H_2SO_4 , sulfuric acid. Acidic hydrogen atoms in acids are generally bound to very electronegative atoms. Both hydrogens in sulfuric acid are acidic.
- (i) NO_3^- , the nitrate ion.
- (j) HNO_3 , nitric acid.
- (k) SF_6
- (l) HCl , hydrochloric acid.
- (m) H_3PO_4 , phosphoric acid. All three hydrogens in this acid are acidic.
- (n) PF_5
6. For (g), (h), (m), and (n) in the problem above, please draw the **modern Lewis structure**.
7. VSEPR: In the trigonal bipyramidal geometry, there are two axial and three equatorial sites. The more electronegative atoms almost always occupy the axial sites. Lone pairs correspond to not having a peripheral nucleus at all. Lone pairs are therefore very electropositive as applied to this rule.
- Please **draw the correct shape** for the following molecules. Please state the SN geometry off of which each shape is based.
- (a) XeF_5^+
- (b) KrO_2F^+
- (c) XeF_4

- (d) XeO_3
- (e) IOF_4^-
- (f) ClOF_2^+
- (g) IOF_5
- (h) OClF
- (i) I_3^-
- (j) SOCl_2
- (k) SO_2F_2

8. *In the shortcut method of determining oxidation states, very electronegative elements typically reach their most normal negative oxidation state. Very electropositive elements typically reach their most normal positive oxidation state.* Please, where possible, use the short-cut method to find the **oxidation states for the atoms** in the molecules and ions below. In difficult cases you may have to use the longer method: the longer method requires the drawing of an accurate Lewis structure.

- (a) POCl_3
- (b) SO_4^{2-} , the sulfate ion.
- (c) SO_2Cl_2
- (d) elemental Ge
- (e) PO_4^{3-} , the phosphate ion.
- (f) $\text{P}_2\text{O}_7^{4-}$
- (g) S_2F_2
- (h) HOOH
- (i) H_2SO_4 , sulfuric acid. Acidic hydrogen atoms in acids are generally bound to very electronegative atoms. Both hydrogen atoms in sulfuric acid are acidic.
- (j) NO_3^- , the nitrate ion.
- (k) HNO_3 , nitric acid.
- (l) HCl , hydrochloric acid.
- (m) H_3PO_4 , phosphoric acid. All three hydrogen atoms in this acid are acidic.
- (n) XeF_5^+
- (o) KrO_2F^+
- (p) XeF_4
- (q) XeO_3
- (r) IOF_4^-
- (s) SiF_6^{2-}
- (t) ClOF_2^+
- (u) elemental iodine

- (v) IOF_5
- (w) OClF
- (x) I_3^-
- (y) SOCl_2
- (z) SO_2F_2