

CHEMISTRY 1A

Spring 2011

EXAM 3 Key

CHAPTERS 7, 8, 9 & part 10

You might find the following useful.

$$PV = nRT \quad R = \frac{0.082058 \text{ L} \cdot \text{atm}}{\text{K} \cdot \text{mol}} \quad \text{or} \quad \frac{8.3145 \text{ L} \cdot \text{kPa}}{\text{K} \cdot \text{mol}}$$

$$PV = \frac{g}{M}RT \quad g = \text{mass} \quad M = \text{molar mass}$$

$$P_{\text{total}} = \sum P_{\text{partial}} \quad \text{or} \quad P_{\text{total}} = (\sum n_{\text{each gas}}) \frac{RT}{V}$$

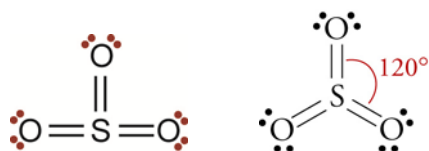
	1	2																	18
	1A	2A							1	2.20			13	14	15	16	17		8A
										H			3A	4A	5A	6A	7A		
2	0.98	1.57											2.04	2.55	3.04	3.44	3.98		
	Li	Be											B	C	N	O	F		
3	0.93	1.31											1.61	1.90	2.19	2.58	3.16		
	Na	Mg											3B	4B	5B	6B	7B	8B	8B
4	0.82	1.00											1.65	1.81	2.01	2.18	2.55	2.96	3.00
	K	Ca											Zn	Ga	Ge	As	Se	Br	Kr
5	0.82	0.95											1.69	1.78	1.96	2.05	2.1	2.66	2.6
	Rb	Sr											Cd	In	Sn	Sb	Te	I	Xe
6	0.79	0.89											2.00	1.62	2.33	2.02	2.0	2.2	
	Cs	Ba											Hg	Tl	Pb	Bi	Po	At	
7	0.7	0.9																	
	Fr	Ra																	

For each of the following, write the word, words, or number in each blank that best completes each sentence. (2 points each)

1. The condition of an atom that has at least one of its electrons in orbitals that do not represent the lowest possible potential energy is called a(n) **excited state**.
2. A(n) **antibonding** molecular orbital is formed from out-of-phase interaction of two atomic orbitals. This leads to a decrease in negative charge between two nuclei where the atomic orbitals overlap and leads to less $+/-$ attraction between the negative charge generated by the electrons and the nuclei.
3. **Isomers** are compounds that have the same molecular formula but different molecular structures.
4. A(n) **unsaturated** fat is a triglyceride that has one or more carbon-carbon double bonds.
5. **Hydrogenation** is a process by which hydrogen is added to an unsaturated triglyceride to convert double bonds to single bonds. This can be done by combining the unsaturated triglyceride with hydrogen gas and a platinum catalyst.
6. A polar molecule or ion (or a portion of a molecule or polyatomic ion) that is attracted to water is called **hydrophilic**.
7. Of the two ionic bonds, Al-S (in Al_2S_3) or Cs-S (in Cs_2S), the **Al-S** bond has the most covalent character.
8. Of the two ions, S^{2-} and Ca^{2+} , the **S^{2-}** is larger.

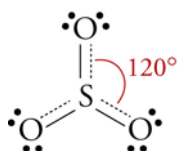
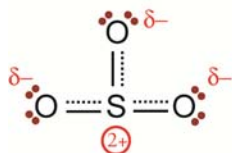
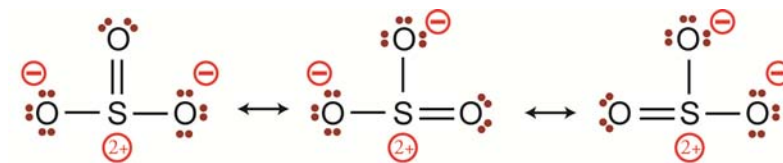
9. There are disagreements among chemists as to how Lewis structures should be drawn. Some feel that we should try to minimize formal charges, others feel we should emphasize the “octet rule”, and others feel that for most of the uses for Lewis structures, it doesn't make any difference. As an example, consider the prediction of the molecular geometry and molecular polarity of sulfur trioxide, SO_3 . (10 points)

- a. Draw a reasonable Lewis structure for SO_3 that minimizes formal charges. This structure does not have resonance. Draw the geometric sketch, including representative bond angles, predicted from this structure. Predict whether, based on this structure, the molecule is polar or nonpolar.



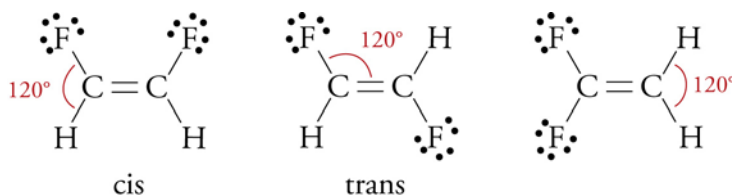
nonpolar (symmetrical distribution of polar bonds)

- b. Draw a reasonable Lewis structure for SO_3 that has eight total electrons around each of the atoms. Identify all formal charges. This structure has resonance, so draw *all* the resonance structures *and* the resonance hybrid. Draw the geometric sketch, including representative bond angles, predicted from this structure. Predict whether, based on this structure, the molecule is polar or nonpolar.



nonpolar (symmetrical distribution of polar bonds)

10. Draw geometric sketches, including representative bond angles for the three isomers of difluoroethene, $\text{C}_2\text{H}_2\text{F}_2$. Label the cis and trans isomers. (8 points)

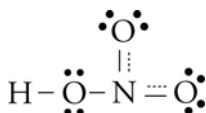


11. Write abbreviated electron configurations for each of the following, (4 points each)

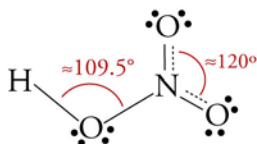
a. Copper atom, Cu [Ar] 3d¹⁰ 4s¹

b. Iridium(II) ion, Ir²⁺ [Xe] 4f¹⁴ 5d⁷

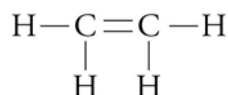
12. Consider the following Lewis Structure for the resonance hybrid for nitric acid, HNO₃. (13 points)



- What is the hybridization for the left oxygen atom? **sp³**
- What is the hybridization for the right oxygen atom? **sp²**
- What is the hybridization for the top oxygen atom? **sp²**
- What is the hybridization for the nitrogen atom? **sp²**
- Write a description of the bonding, stating whether each bond is sigma, pi, or part of a delocalized pi system and by stating which atomic orbitals overlap to form the bonds.
 - 1 sigma O-H bond due to sp³-1s overlap**
 - 1 sigma O-N bond due to sp³-sp² overlap**
 - 2 sigma N-O bonds due to sp²-sp² overlap**
 - 1 delocalized pi system due to 3 p orbitals overlapping, one on the nitrogen atom, one on the top oxygen atom, and one on right oxygen atom**
- What is the name of the electron group geometry around the left O? **tetrahedral**
- What is the name of the electron group geometry around the nitrogen? **trigonal planar**
- Draw a sketch with bond angles.

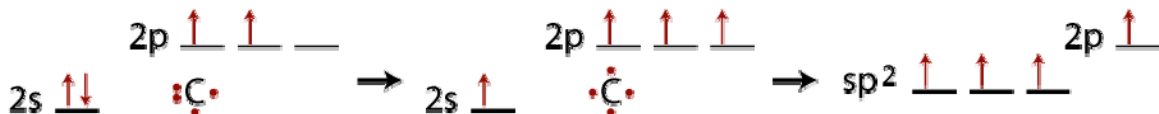


13. Consider the following Lewis Structure for C₂H₄. (11 points)



- a. With reference to the assumptions of the valence bond model of covalent bonding, and using orbital diagrams for the valence electrons of carbon, explain how carbon atoms are able to form the bonds in C₂H₄. Describe each bond as a sigma or pi bond and tell how each is formed from the overlap of atomic orbitals.

Only the highest energy electrons participate in bonding.



Covalent bond form to pair unpaired electrons.

Two sp² atomic orbitals for each carbon overlap 1s orbitals of the hydrogen atoms to form 2 sigma bonds.

One sp² atomic orbital for each carbon overlaps an sp² orbital of the other carbon to form a sigma bond.

The unhybridized 2p atomic orbitals of the carbons overlap to form a pi bond.

- b. Explain why one of the bonds in the double bond is weaker than the other.

The p orbitals, which form the pi bond by parallel overlap, overlap less than the sp² atomic orbitals, which form the sigma bond by end-on overlap.

Less overlap leads to less of an increase in negative charge between the nuclei and therefore, less of a stabilization of the molecule.

14. For each of the following, write the name of the type of attraction holding these particles in the solid and liquid form. Indicate the formula in each pair that represents the substance that you would expect to have the higher melting point and boiling point. (3 points each)

a. Iodine trifluoride, IF_3

type of attraction **dipole-dipole and London forces**

or ethyl amine, $\text{C}_2\text{H}_5\text{NH}_2$

type of attraction **hydrogen bonds and London forces**

higher melting point and boiling point? **$\text{C}_2\text{H}_5\text{NH}_2$**

b. 2-aminopropane, $\text{CH}_3\text{CH}(\text{NH}_2)\text{CH}_3$

type of attraction **hydrogen bond and London forces**

or 2-aminodecane, $\text{CH}_3\text{CH}(\text{NH}_2)(\text{CH}_2)_7\text{CH}_3$

type of attraction **hydrogen bond and London forces**

higher melting point and boiling point? **$\text{CH}_3\text{CH}(\text{NH}_2)(\text{CH}_2)_7\text{CH}_3$**

c. Ammonium hydroxide, NH_4OH

type of attraction **ionic bonds**

or octane, C_8H_{18}

type of attraction **London forces**

stronger attractions? **NH_4OH**

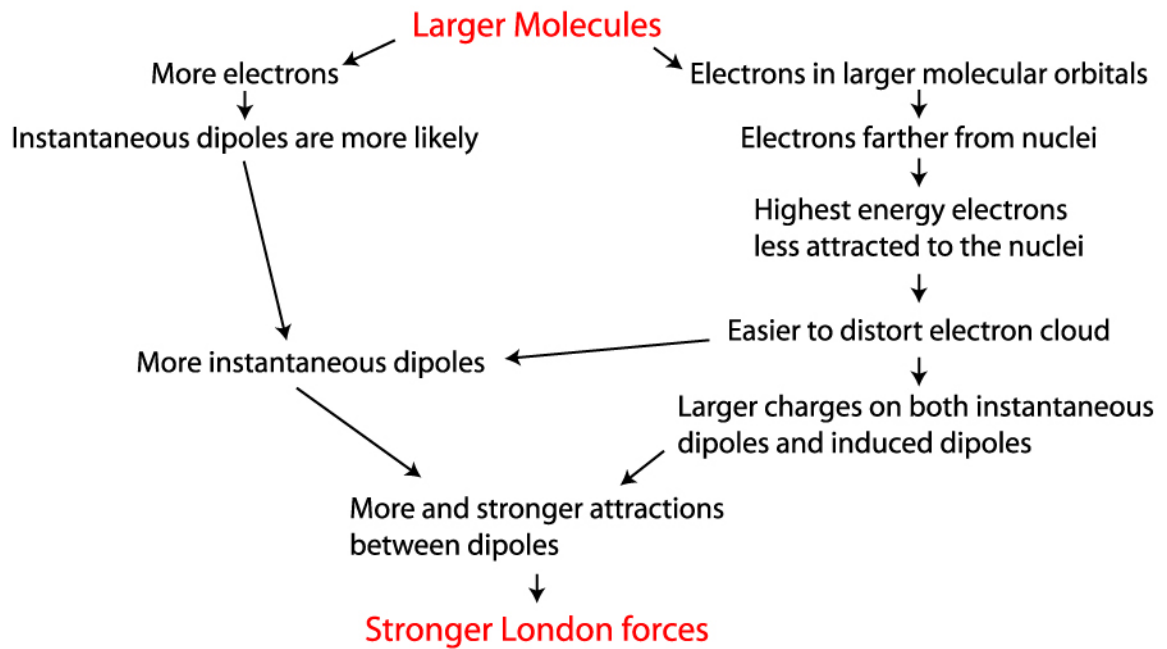
15. Ammonia and carbon dioxide combine to produce urea, NH_2CONH_2 , and water through the following reaction. About 90% of the urea is used to make fertilizers, but some is also used to make animal feed, plastics, and pharmaceuticals. The concentration of urea in a typical liquid fertilizer is about one molar NH_2CONH_2 . What minimum volume of NH_3 at 190°C and 34.0 atm is needed to make $3.5 \times 10^4\text{ L}$ of $1.0\text{ M NH}_2\text{CONH}_2$? (8 points)



$$\begin{aligned} ?\text{ L NH}_3 &= 3.5 \times 10^4\text{ L NH}_2\text{CONH}_2 \text{ soln} \left(\frac{1.0\text{ mol NH}_2\text{CONH}_2}{1\text{ L NH}_2\text{CONH}_2 \text{ soln}} \right) \left(\frac{2\text{ mol NH}_3}{1\text{ mol NH}_2\text{CONH}_2} \right) \\ &\left(\frac{0.082058\text{ L}\cdot\text{atm}}{\text{K}\cdot\text{mol}} \right) \left(\frac{463\text{ K}}{34.0\text{ atm}} \right) = 7.8 \times 10^4\text{ L NH}_3 \end{aligned}$$

Answer the following in short answer form. (8 points each)

41. Explain why larger molecules have stronger London Forces.



42. Explain why lowering the temperature of a gas **and/or** why increasing the concentration of a gas (by adding gas to a container and/or decreasing the available volume) leads to a greater difference between the pressure calculated from the ideal gas equation and the real or measured pressure. (8 points)

