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AP Chemistry

# Unit 2 Problem Set Packet

## Bonding Problem Set #1

### Electronegativity, Isoelectronic Series, Lattice Energy and Ionic Structure

- Only using the periodic table and without looking up values, predict the order of increasing electronegativity in each of the following groups of elements.
  - C, N, O
  - S, Se, Cl
  - Si, Ge, Sn
- Only using the periodic table and without looking up values, predict which bond in each of the following groups will be the most polar.
  - C—F, Si—F, Ge—F
  - P—Cl or S—Cl
  - S—F, S—Cl, S—Br
- Indicate the bond polarity (show the partial positive and partial negative ends) in the following bonds
  - C—O
  - P—H
  - H—Cl
  - Br—Te
- Predict the type of bond (ionic, nonpolar covalent, or polar covalent) one would expect to form between the following pairs of elements.
  - Rb and Cl
  - S and S
  - C and F
  - Ba and S
  - B and H
- Give the formula of a NEGATIVE ion that would be isoelectronic with each of the following POSITIVE ions.
  - Na<sup>+</sup>
  - Ca<sup>2+</sup>
  - Al<sup>3+</sup>
  - Rb<sup>+</sup>
- Give three ions that are isoelectronic with neon. Place these ions in order of increasing size.

7. Rank the following ions and atoms in order from smallest radius to largest radius. Justify your choice.  
 $K^+$ ,  $S^{2-}$ ,  $Br^-$ ,  $Sr^{2+}$ ,  $Ar$ ,  $Cl^-$ ,  $Kr$
8. Identify any isoelectronic series in the ions below. For each isoelectronic series, order the species from smallest radius to largest radius. Justify your grouping and ordering.  
 $Fe^{2+}$ ,  $Sc^{3+}$ ,  $Ca^{2+}$ ,  $F^-$ ,  $Co^{2+}$ ,  $Sr^{2+}$ ,  $Cu^+$ ,  $Zn^{2+}$ ,  $Al^{3+}$
9. Explain, in terms of atomic structure and Coulombic attraction, why  $CaSe$  has a lattice energy of  $-2862$  kJ/mol whereas  $Na_2Se$  has a lattice energy of  $-2130$  kJ/mol.
10. The lattice energies of  $FeCl_3$ ,  $FeCl_2$ , and  $Fe_2O_3$  are (in no particular order)  $-2631$ ,  $-5359$ , and  $-14,774$  kJ/mol. Match the appropriate formula to each lattice energy and justify your choice.
11. Rank the following compounds in order from most to least lattice energy. Justify your ranking.  
 $MgF_2$ ,  $NaF$ ,  $CaO$ ,  $CsI$

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## Bonding Problem Set #2

### Models of Structures

Draw a model in the space below of both a substitutional alloy and an interstitial alloy. Make sure your model is labeled or has a key.

Substitutional Alloy	Interstitial Alloy

Using words, describe the difference between substitutional and interstitial alloys in the space below. Specifically reference the sizes of the atoms involved.

Draw a model in the space below that illustrates why ionic solids are brittle when struck and typically cleave in two.



Using words, explain your model. Why do ionic solids split so easily when struck?

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## Bonding Problem Set #3

### Drawing Lewis Structures

1. Draw Lewis structures for the following compounds. **Obey the octet rule where possible.**

SeCl <sub>2</sub>	SO <sub>3</sub> <sup>2-</sup>
CO <sub>3</sub> <sup>2-</sup>	SO <sub>2</sub>
H <sub>2</sub> CO (C is central atom)	SO <sub>3</sub>

$\text{PO}_4^{3-}$	$\text{XeO}_4$
$\text{KrF}_2$	$\text{H}_3\text{O}^+$

2. One type of exception to the octet rule are compounds with central atoms having fewer than eight electrons around them.  $\text{BeH}_2$  and  $\text{BH}_3$  are examples of this type of exception. Draw the Lewis structures for  $\text{BeH}_2$  and  $\text{BH}_3$ .
  
3. Lewis structures can be used to understand why some molecules react in certain ways. Write the Lewis structures for the reactants and products in the reactions described below.
  - a. Nitrogen dioxide dimerizes (two of them combine) to produce dinitrogen tetroxide.
  
  - b. Give a possible explanation for why this reactions occur, referencing the Lewis structures you drew in part a.



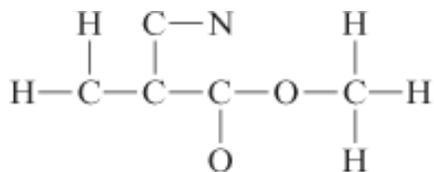
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## Bonding Problem Set #4

### Resonance, Formal Charge, and Bond Order

- For each of the following compounds,
  - Write Lewis structures
  - Show all resonance structures where applicable
  - Determine formal charge for each element in the compound.
  - $\text{N}_2\text{O}_4$
  - $\text{SO}_2$
  - $\text{SO}_3$
  - Borazine ( $\text{B}_3\text{N}_3\text{H}_6$ ). Borazine contains a six-membered ring of alternating boron and nitrogen atoms with one hydrogen bonded to each boron and nitrogen.
- Consider the following bond lengths:  
C-O 143 pm      C=O 123 pm      C $\equiv$ O 109 pm  
In the  $\text{CO}_3^{2-}$  ion, all three C-O bonds have identical bond lengths of 136 pm.
  - Draw Lewis structures for carbonate that can explain this observation AND provide a written explanation of how your structures can account for this observation.
  - What is the bond order for the carbon to oxygen bond in the carbonate ion?

3. A common trait of simple organic compounds is to have Lewis structures where all atoms have a formal charge of zero. Consider the following incomplete Lewis structure for an organic compound called *methyl cyanoacrylate*, the main ingredient in Super Glue.



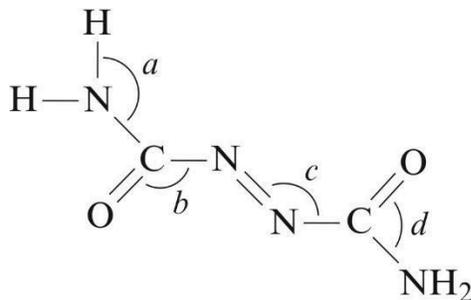
- a. Draw a complete Lewis structure for methyl cyanoacrylate in which all atoms have a formal charge of zero. You may do that either by completing the structure above, or redrawing the complete structure in the space below.
  - b. Determine the bond order for each bond in your Lewis structure. Write the bond order in next to the bond on your Lewis Structure.
4. Nitrous oxide ( $\text{N}_2\text{O}$ ) has three possible Lewis resonance structures.
- a. Draw them (N is the central atom).
  - b. What is the bond order for the nitrogen to oxygen bond? What is the bond order for the nitrogen to nitrogen bond?
5. Oxidation of the cyanide ion produces the stable cyanate ion,  $\text{OCN}^-$ . The fulminate ion,  $\text{CNO}^-$ , on the other hand, is very unstable. Fulminate salts explode when struck;  $\text{Hg}(\text{CNO})_2$  is used in blasting caps.
- a. Write the Lewis structures and assign formal charges for the cyanate and fulminate ions. (C is the central atom in  $\text{OCN}^-$  and N is the central atom in  $\text{CNO}^-$ )
  - b. Why is the fulminate ion so unstable? Explain on the basis of formal charge.

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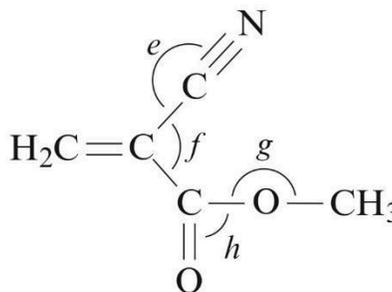
## Bonding Problem Set #5

### Sigma vs. Pi Bonds

1. Two molecules used in the polymer industry are azodicarbonamide and methyl cyanoacrylate. Their structures are:



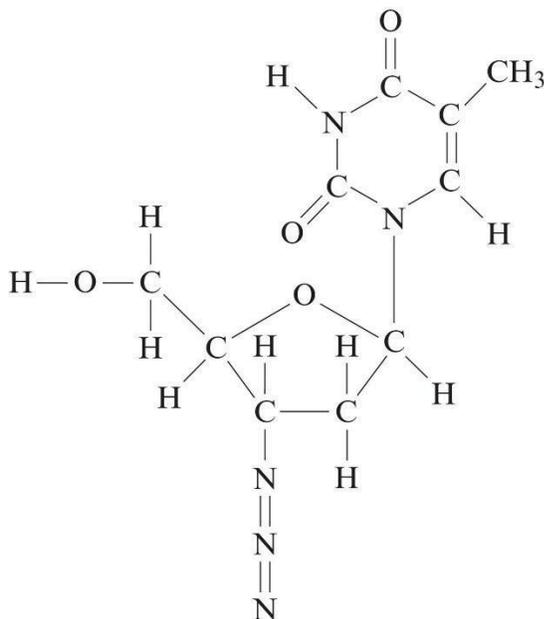
**Azodicarbonamide**



**Methyl cyanoacrylate**

- Complete the Lewis structures above by showing all lone pairs of electrons.
- What is the hybridization of the carbon atoms in azodicarbonamide?
- How many  $\sigma$  bonds are present in each structure?  
Azodicarbonamide: \_\_\_\_\_  
Methyl cyanoacrylate: \_\_\_\_\_
- How many  $\pi$  bonds are present in each structure?  
Azodicarbonamide: \_\_\_\_\_  
Methyl cyanoacrylate: \_\_\_\_\_
- Give approximate values of the bond angles marked *a* through *h* in the above structures.

2. One of the first drugs to be approved for use in treatment of acquired immune deficiency syndrome (AIDS) was azidothymidine (AZT), shown below.



- Complete the Lewis structure for AZT by filling in lone pairs.
- How many carbon atoms are  $sp^2$  hybridized?
- How many carbon atoms are  $sp^3$  hybridized?
- How many  $\sigma$  bonds are in the molecule?
- How many  $\pi$  bonds are in the molecule?
- What is the  $N=N=N$  bond angle in the azide ( $-N_3$ ) group?
- What is the  $H-O-C$  bond angle in the side group attached to the five-membered ring?