Unit 2 Review for Midterms

Molecular and ionic compound structure and properties

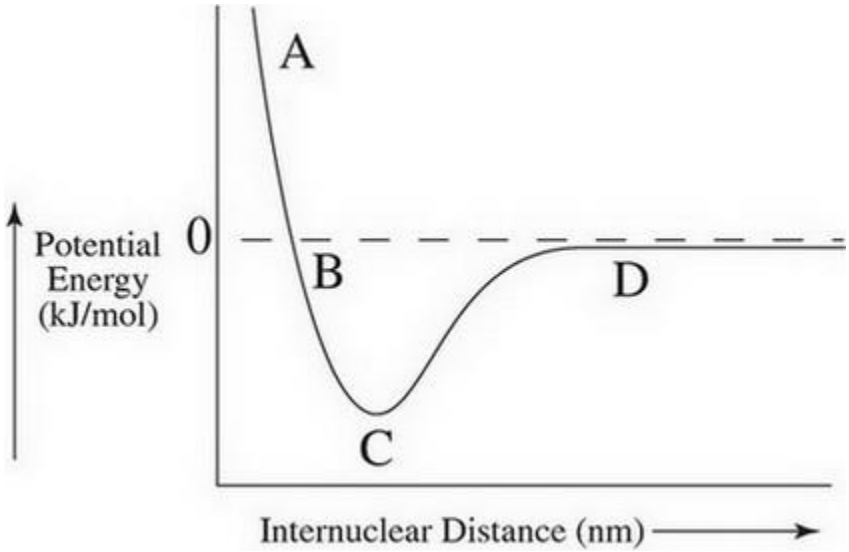
You should be able to:

- Understand and explain the trend in electronegativity values
- Differentiate between a polar and nonpolar bonds and bond dipoles on the basis of electronegativity values
- Differentiate between ionic and covalent bonding on the basis of a compound's properties
- Interpret a graph of potential energy versus the distance between atoms
- Understand the relationship between bond length, bond size, and bond energy
- Relate Coulomb's law and the strength of interactions between cations and anions
- Represent ionic solids as crystal structures that are consistent with Coulomb's law and ion properties
- Explain how properties of metallic solids are related to metallic bonding
- Differentiate between interstitial and substitutional alloys and how alloying a metal affects its properties
- Draw Lewis diagrams and resonance structures (where applicable)
- Evaluate which Lewis diagram best predicts molecular structure using the octet rule and formal charges
- Use VSEPR theory to predict molecular geometry, bond angles
- Relate bond order to bond energies and bond lengths
- Predict the hybridization of a molecule
- Understand sigma (σ) and pi (π) bonding

1. Determine the type of bonds for each substance in the table. Explain why you chose this type.

Substance	Melting point (°C)	Electrical conductor when solid?	Electrical conductor when liquid?
A	400	No	Yes
B	2000	Yes	Yes
C	-6	No	No
D	3500	No	No

2. Use the graph of potential energy vs distance between two atoms bonding covalently to answer the following questions:



   a. Explain the interactions and forces between the two atoms at points A, B, C, and D.
   b. Which point indicates the equilibrium bond length between the two atoms?
   c. How much energy is needed to break the covalent bond between these atoms? Is this energy positive or negative?
   d. On the graph, sketch a new diagram for the interactions between two larger atoms. Explain any differences.

3. Draw particulate representations (molecule drawings) for each of the following:
   a. Several water molecules
   b. Several sodium chloride formula unites
   c. Several carbon atoms in a diamond
   d. Several copper atoms in a solid
   e. Several particles in a substitutional alloy (like gold and silver)
   f. Several particles in an interstitial alloy (like iron and carbon)

4. For each of the following bonds, Na—F, Mg—F, C—F, O—F, F—F
   a. Identify which atom is more electronegative
   b. If the bond is more ionic or covalent in character
   c. If the covalent bond is polar or nonpolar
   d. Which covalent bond is the most polar? Least polar?

5. For NaCl and $MgCl_2$:
   a. Show the transfer of electrons to form oppositely charged ions
   b. Why does one atom readily give up electrons? Which type of atoms are these?
   c. What is lattice energy?
   d. Which compound will have a higher lattice energy? Why?

6. Draw Lewis diagrams, identify the electron domain geometry and molecular geometry, and determine bond angles of:
    a. Phosphorus trichloride
    b. Oxygen
    c. Carbon dioxide
    d. H_2CO
    e. Chlorite ion
    f. NO^+ ion
    g. Phosphorus pentafluoride
    h. Iodine trichloride
    i. Xenon difluoride

7. For the following molecules/ions, draw all possible resonance structures. Use formal charges to determine the dominant Lewis diagram.
    a. NCS^-
    b. O_3
    c. Nitrate ion
    d. Sulfur trioxide
    e. Sulfate ion

8. For the carbonate ion,
    a. Draw all possible resonance structures
    b. Which carbon – oxygen bond will be the longest? Shortest? Strongest? Explain.

9. For C_2H_2, C_2H_4, and C_2H_6
    a. Draw the Lewis structures
    b. Label all bonds as sigma (σ) or pi (π) with numbers of each
    c. Which carbon – carbon bonds are the shortest? Longest? Strongest?
    d. Identify the hybridization of each carbon.

AP Questions

1. Answer the following questions about the isomers fulminic acid and isocyanic acid.

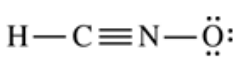
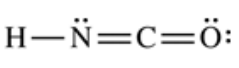
    Two possible Lewis electron-dot diagrams for fulminic acid, HCNO, are shown below.

    a. Explain why the diagram on the left is the better representation for the bonding in fulminic acid. Justify your choice based on formal charges.

Fulminic acid can convert to isocyanic acid according to the equation below.

$$HCNO(g) \rightleftarrows HNCO(g)$$

fulminic acid - isocyanic acid

Fulminic Acid	Isocyanic Acid
	

b. Using the Lewis electron-dot diagrams of fulminic acid and isocyanic acid shown in the boxes above and the table of average bond enthalpies below, determine the value of $\Delta H°$ for the reaction of HCNO(*g*) to form HNCO(*g*).

Bond	Enthalpy (kJ/mol)		Bond	Enthalpy (kJ/mol)		Bond	Enthalpy (kJ/mol)
N–O	201		C=N	615		H–C	413
C=O	745		C≡N	891		H–N	391

2. Answer the following questions using principles of chemical bonding and molecular structure.

   a. Consider the carbon dioxide molecule, CO_2, and the carbonate ion, CO_3^{2-}.

   b. Draw the complete Lewis electron-dot structure for each species.

   c. Account for the fact that the carbon-oxygen bond length in CO_3^{2-} is greater than the carbon-oxygen bond length in CO_2.

   d. Consider the molecules CF_4, and SF_4.

   e. Draw the complete Lewis electron-dot structure for each molecule.

   f. In terms of molecular geometry, account for the fact that the CF_4 molecule is nonpolar, whereas the SF_4 molecule is polar.

3.

Compound Name	Compound Formula	ΔH^{o}_{vap} (kJ mol^{-1})
Propane	$CH_3CH_2CH_3$	19.0
Propanone	CH_3COCH_3	32.0
1-propanol	$CH_3CH_2CH_2OH$	47.3

Using the information in the table above, answer the following questions about organic compounds.

a. For propanone,

   i. draw the complete structural formula (showing all atoms and bonds);

   ii. Predict the approximate carbon-to-carbon-to-carbon bond angle.

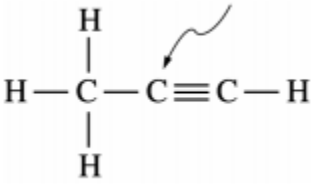
b. For each pair of compounds below, explain why they do not have the same value for their standard heat of vaporization, $\Delta H°_{vap}$, (You must include specific information about <u>both</u> compounds in each pair.)

   i. Propane and propanone

   ii. Propanone and 1-propanol

c. Draw the complete structural formula for an isomer of the molecule you drew in part (a) (i).

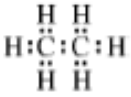
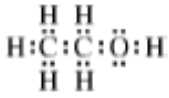
d. Given the structural formula for propyne below,



   i. indicate the hybridization of the carbon atom indicated by the arrow in the structure above;

   ii. Indicate the total number of sigma (σ) bonds and the total number of pi (**π**) bonds in the molecule.

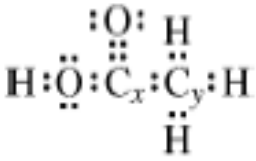
4. Use the information in the table below to respond to the statements and questions that follow. Your answers should be in terms of principles of molecular structure and intermolecular forces.

Compound	Formula	Lewis Electron-Dot Diagram
Ethanethiol	CH_3CH_2SH	
Ethane	CH_3CH_3	
Ethanol	CH_3CH_2OH	
Ethyne	C_2H_2	

a. Draw the complete Lewis electron-dot diagram for ethyne in the appropriate cell in the table above.

b. Which of the four molecules contains the shortest carbon-to-carbon bond? Explain.

c. A Lewis electron-dot diagram of a molecule of ethanoic acid is given below. The carbon atoms in the molecule are labeled x and y, respectively.



Identify the geometry of the arrangement of atoms bonded to each of the following.

i. Carbon *x*
ii. Carbon *y*

d. Energy is required to boil ethanol. Consider the statement “As ethanol boils, energy goes into breaking C−C bonds, C−H bonds, C−O bonds, and O−H bonds.” Is the statement true or false? Justify your answer.

e. Identify a compound from the table above that is nonpolar. Justify your answer.

f. Ethanol is completely soluble in water, whereas ethanethiol has limited solubility in water. Account for the difference in solubilities between the two compounds in terms of intermolecular forces.