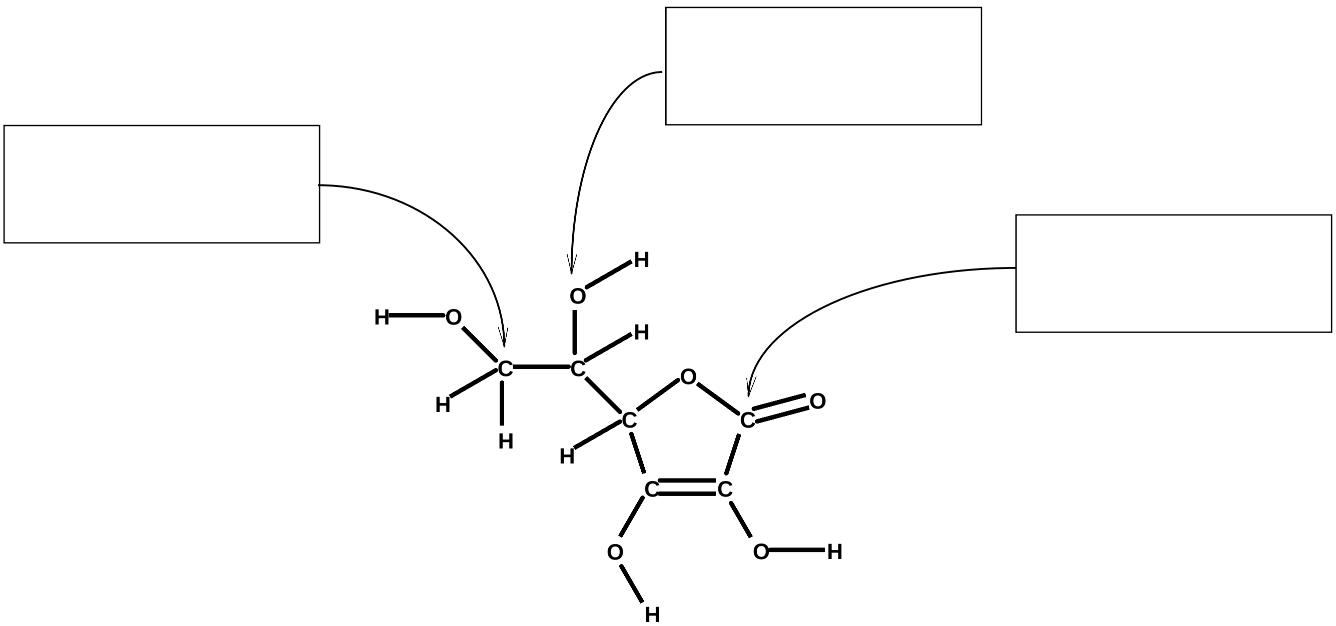
Practice Test Questions 5B
Valence Bond Theory

1. The molecule below is ascorbic acid, more commonly known as Vitamin C. Consider this molecule according to valence bond theory.

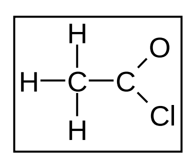


(a) Complete the Lewis structure by adding all missing lone pairs of electrons.

(b) Name the hybrid orbital set used by each of the three atoms identified by arrows. Also, indicate the number of unhybridized 2*p* orbitals remaining on each of these atoms. *Answer in the boxes provided.*

(c) How many σ bonds are there in one molecule of ascorbic acid?

(d) How many π bonds are there in one molecule of ascorbic acid?



2. Acetyl chloride (CH_3COCl) has the connectivity shown:

(a) Draw the best Lewis structure for acetyl chloride.

(b) Indicate the molecular geometry at each central atom.

C (of CH_3) = ______________________ C (of COCl) = ________________________

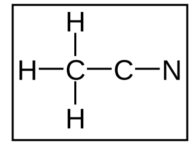
(c) What is the hybridization of the following atoms when VB theory is applied to acetyl chloride:

C (of CH_3) = _________ C (of COCl) = _________

(d) How many sigma bonds are there in one molecule of acetyl chloride? ______

(e) How many pi bonds are there in one molecule of acetyl chloride? ______

3. Acetonitrile (CH_3CN) has the connectivity shown:



(a) Draw the best Lewis structure for acetonitrile.

(b) Indicate the molecular geometry at each central atom.

C (of CH_3) = ______________________ C (of CN) = __________________________

(c) What is the hybridization of the following atoms when VB theory is applied to acetonitrile:

C (of CH_3) = _________ C (of CN) = _________

(d) How many sigma bonds are there in one molecule of acetonitrile? ______

(e) How many pi bonds are there in one molecule of acetonitrile? ______

4. Use diagram(s) to explain how *sp* orbitals are formed. *Clearly indicate the number, type and geometry of all orbitals involved.*

5. Use diagrams in your answers to the following questions.

(a) What is the main difference between a hybrid atomic orbital and a molecular orbital?

(b) What is the main difference between a σ bond and a π bond?

6. Briefly, explain why atomic orbitals in diatomic molecules are not typically hybridized.

7. Describe two key differences between molecular orbital theory and valence bond theory.

8. All pictures for this question must be drawn to show the molecule's three-dimensional shape. Use wedges and/or dashed lines as necessary.

(a) Draw a molecule containing at least one carbon atom that would be considered sp^3-hybridized according to valence bond theory. If your molecule contains more than one carbon atom, it must be clear which carbon atom(s) is/are sp^3-hybridized.

(b) Draw a molecule containing at least one carbon atom that would be considered sp^2-hybridized according to valence bond theory. If your molecule contains more than one carbon atom, it must be clear which carbon atom(s) is/are sp^2-hybridized.

(c) Draw a molecule containing at least one carbon atom that would be considered *sp*-hybridized according to valence bond theory. If your molecule contains more than one carbon atom, it must be clear which carbon atom(s) is/are *sp*-hybridized.

9. Consider the bonding in HCN according to valence bond theory.

(a) Draw a Lewis structure for HCN.

(b) What is the hybridization of the carbon atom in HCN?

(c) Clearly indicate *using a sketch of the sigma-framework* which atomic orbitals combine to make each σ bond in HCN. Include electron pairs and label each atomic or hybrid orbital clearly.

(d) Clearly indicate *using a sketch of just the pi-network* which atomic orbitals combine to make each π bond in HCN. Include electron pairs and label each atomic or hybrid orbital clearly.

10. What structure is expected for $[H_2CCH_2]^{2+}$? Using a valence bond analysis, provide a concise, **clear answer** and make a clear sketch of the structure you suggest, using "wedges and dashes" notation.