Before you begin this exam: First: You are allowed to have a simple model set at your seat. Please put away all other materials. Calculators will not be needed. Second: Place your student identification on your desk. A proctor will come around to check everyone’s ID. Third: Read through the entire exam. Your goal, as always, is to score as many points as possible. Do not waste time on problems that you can’t do if there are others that look easy. Fourth: READ EACH QUESTION CAREFULLY. Be sure you answer the question that is asked. Fifth: This exam must be turned in by 8:50 AM SHARP. There will be no extensions, so budget your time carefully.

1. 11 points  
2. 10 points  
3. 8 points  
4. 3 points  
5. 10 points  
6. 9 points  
7. 6 points  
8. 6 points  
9. 12 points  
10. 15 points  
11. 10 points  

100 points
1. (11 points) Draw the Lewis dot structure for the molecule shown below. **Please draw the valence electrons as dots. Do not draw bonds or non-bonding electron pairs as lines.** In both cases, all atoms are neutral and (other than H) all have complete octets. Be sure that you draw all of the valence electrons.

![Lewis dot structure](image)

2. (10 points) Determine the formal charges on the indicated atoms in the structures below. All non-bonding electrons are shown.

![Structures with charge](image)

Charge on O = +1  
Charge on C = -1  
Charge on C = +1  
Charge on O = 0  
Charge on N = 0

3. (8 points) What is the hybridization of each nitrogen atom in nicotine? What specific orbital does the lone pair of each nitrogen reside in?

![Nicotine structure](image)

Hybridization: $sp^3$  
Lone pair in $sp^3$ hybrid orbital  
Hybridization: $sp^2$  
Lone pair in $sp^2$ hybrid orbital
4. (3 points) Shown below are two resonance forms for dimethyl sulfoxide (DMSO). It is known that the bonding arrangement around the sulfur atom in DMSO is roughly tetrahedral. Circle the resonance form that is the major contributor to the hybrid.

![Resonance Forms for DMSO](image)

5. (10 points) Circle the **MOST** acidic compound in each pair below.

a) ![Molecules](image)

b) ![Molecules](image)

c) ![Molecules](image)

d) ![Molecules](image)

e) ![Molecules](image)
6. **(9 points)** Which is the *longer* of the labeled bonds in each compound?

![Diagrams of labeled bonds with numerals 1 to 6]

7. **(6 points)** Circle structure(s) that are valid resonance forms of compound A.

![Set of resonance structures for compound A]

8. **(6 points)** What are the pKa’s for the most acidic protons in the compounds below? Your answers need to be within ±2 pKₐ units to earn credit (± 5 for pKₐ’s above 40).

   a) ![Diagram of a molecule with a pKa = 20]

   b) ![Diagram of a molecule with a pKa = 4.7]

   c) ![Diagram of a molecule with a pKa = 47]
9. (12 points) For each of the acid-base equilibria below, predict whether Keq is greater than 1 or less than 1. Write your answers to the right of each equation.

\[
\text{PhOH} + \text{NaOH} \rightleftharpoons \text{PhO}^{-} \text{Na}^{+} + \text{H}_{2}\text{O} > 1
\]

\[
\text{H}_{2}\text{N} = \text{NH} + \text{NH}_{4}^{+} \rightleftharpoons \text{H}_{2}\text{N} \text{NH}_{2}^{+} + \text{NH}_{3} > 1
\]

\[
\text{FCH}_{2}\text{COH} + \text{CO}_{2}\text{Na}^{+} \rightleftharpoons \text{FCH}_{2}\text{CO}^{-} \text{Na}^{+} + \text{CO}_{2}\text{H} > 1
\]

10. (15 points) Give the names of the circled functional groups in the compound shown below.

Atorvastatin (Lipitor)

Amide    Hydroxyl    Carboxylic acid
10. Continued...

11. (10 points) The $pK_a$ of methane is 45 - 50, but the $pK_a$ of nitromethane is 10. Draw the conjugate base and explain (one sentence!) why nitromethane is so acidic. **Do not exceed the space provided.**

Unlike the CH$_3$- anion, the nitromethane anion is stabilized by resonance, so the conjugate acid (nitromethane) is stronger than methane.