**Chemistry 1B, Final Exam Part 1** Name KEY
**August 8, 2012**
**Professor L.J. Sperling** TA ____________

| | | |
|---|---|---|
| 1-10 | (30) | ______ |
| 11. | (25) | ______ |
| 12. | (30) | ______ |
| 13. | (15) | ______ |
| 14. | (10) | ______ |
| 15. | (20) | ______ |
| 16. | (20) | ______ |

**TOTAL EXAM SCORE (150)** ______

**Rules:**
- Work all problems to 3 significant figures
- No lecture notes or books permitted
- No word processing calculators
- Time: 90 minutes
- Show all work to get partial credit
- Periodic Table, Table of Physical Constants/Conversion Factors, and Standard Electrochemical Potentials included at back of exam
- **You should have a total of 10 pages in this booklet (including this page)!**

Multiple Choice Answer Sheet (3 points each):

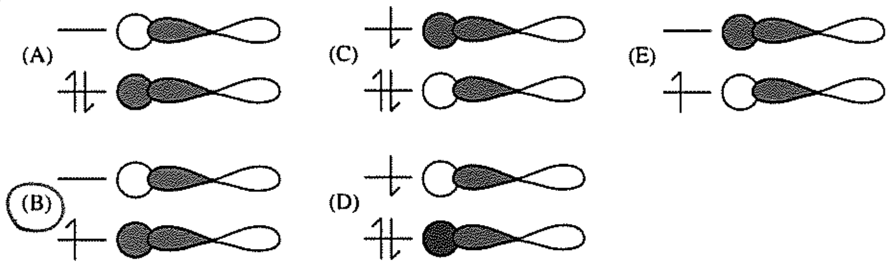
1. B
2. C
3. A
4. D
5. A
6. B
7. E
8. C
9. D
10. E

**Multiple Choice Section. Answer each of the following questions and list your answers on page 2 in the space provided. Each multiple-choice question is worth 3 points.**

---

Consider the $HF^+$ molecule.

**1.** Which MO diagram showing 1s(H) and $2p_z$(F) orbitals best describes the bonding in the lowest energy state?




**2.** Rank the energy of the 1s(H) and $2p_z$(F) orbitals relative to the newly formed molecular orbitals above ($\sigma_{1s,2p}$ $\sigma^*_{1s,2p}$)?

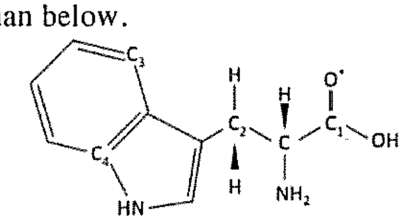
(A) $\sigma_{1s,2p} <$ 1s(H) = $2p_z$(F) $< \sigma^*_{1s,2p}$
(B) $\sigma_{1s,2p} =$ 1s(H) = $2p_z$(F) $= \sigma^*_{1s,2p}$
(C) $\sigma_{1s,2p} <$ 1s(H) $>$ $2p_z$(F) $< \sigma^*_{1s,2p}$
(D) $\sigma_{1s,2p} >$ 1s(H) $>$ $2p_z$(F) $> \sigma^*_{1s,2p}$
(E) $\sigma_{1s,2p} >$ 1s(H) = $2p_z$(F) $> \sigma^*_{1s,2p}$

**3.** Rank the strength of the bond in HF versus $HF^+$ and versus $HF^-$?

(A) $HF^+ = HF^- < HF$
(B) $HF^+ < HF < HF^-$
(C) $HF^+ > HF > HF^-$
(D) $HF^+ = HF = HF^-$

---

Given the structure of Tryptophan below.




**4.** What is the hybridization of the carbons, $C_1$ and $C_2$, respectively in this amino acid as labeled on the structure above?

(A) both sp (B) both $sp^2$ (C) both $sp^3$ (D) $sp^2$; $sp^3$ (E) $sp^3$; $sp^2$

**5.** What is the hybridization of the carbons, $C_3$ and $C_4$, respectively in this amino acid as labeled on the structure above?

(A) both $sp^2$ (B) both $sp^3$ (C) $sp^3$;$sp^2$ (D) $sp^2$; $sp^3$ (E) sp; $sp^2$

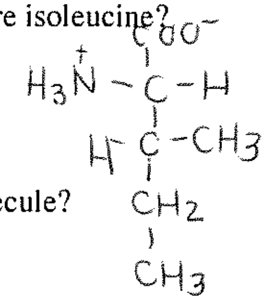
**6.** What is the hybridization of the oxygen, O*, in this amino acid as labeled on the structure above?

(A) sp (B) $sp^2$ (C) $sp^3$ (D) $dsp^3$ (E) $d^2sp^3$

---

7. How many resonances (or signals) will there be in a $^{13}C$ NMR spectrum of pure isoleucine?

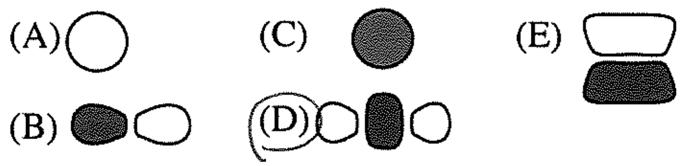
(A) 2 (B) 3 (C) 4 (D) 5 (E) 6




8. In $N_2$ how many p-orbitals from each nitrogen form the pi bond(s) in this molecule?

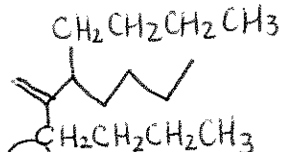
(A) 0 (B) 1 (C) 2 (D) 3 (E) 4

9. Which of the following orbitals has the highest energy?




10. How many carbons are in the molecule 2,3-dibutyl-heptene?

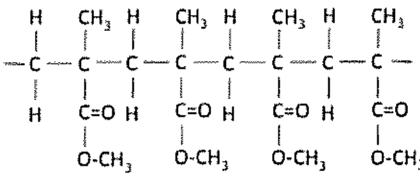
(A) 7 (B) 12 (C) 13 (D) 14 (E) 15

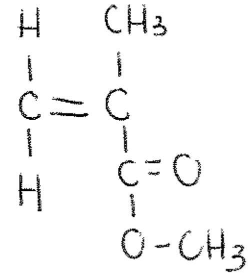



**NOTE: Don't forget to go back and list your answers on page 2 in the space provided!!**

**Calculations Section. Please show ALL work to receive partial credit. Place your final answers in a circle or box for clarity.**

**11. (25 points)** (a) Poly(methyl methacrylate) or PMMA is synthesized through the addition polymerization reaction. Using the polymer structure below draw the starting material.

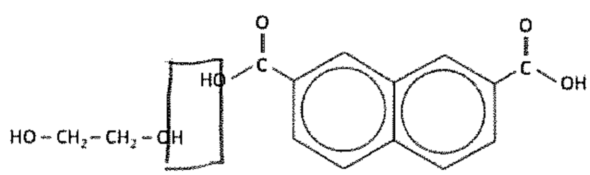


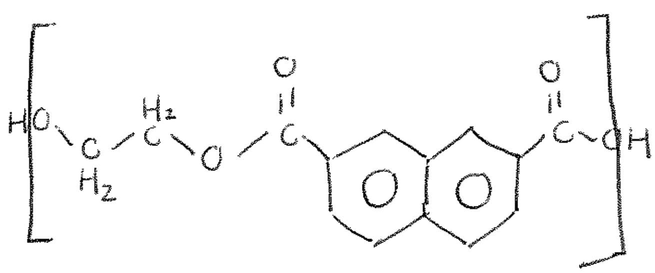


(b) Does this reaction require an *initiator* to begin polymerization of PMMA?

Yes

(c) The synthesis of polyethylene naphthalate or PEN occurs through a condensation reaction from the two molecules shown below. Draw one repeat unit of the resulting polyethylene naphthalate.





(d) Does this reaction require an *initiator* to begin polymerization of PEN?

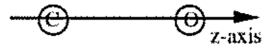
No

(e) What is the mass in grams of HO-$CH_2$-$CH_2$-OH necessary to synthesize 10 kg of polyethylene naphthalate? (The molar mass of the repeat unit for polyethylene naphthalate is 260.25 g/mol. The molar mass of HO-$CH_2$-$CH_2$-OH is 62.07 g/mol.)

$$10.0\text{ kg} \times \frac{1000\text{ g}}{1\text{ kg}} \times \frac{1\text{ mol}}{260.25\text{ g}} = 38.42\text{ mol repeat units}$$

$$38.42\text{ mol HO-CH}_2\text{-CH}_2\text{-OH} \times \frac{62.07\text{ g}}{1\text{ mol}} = \boxed{2385.01\text{ g}}$$

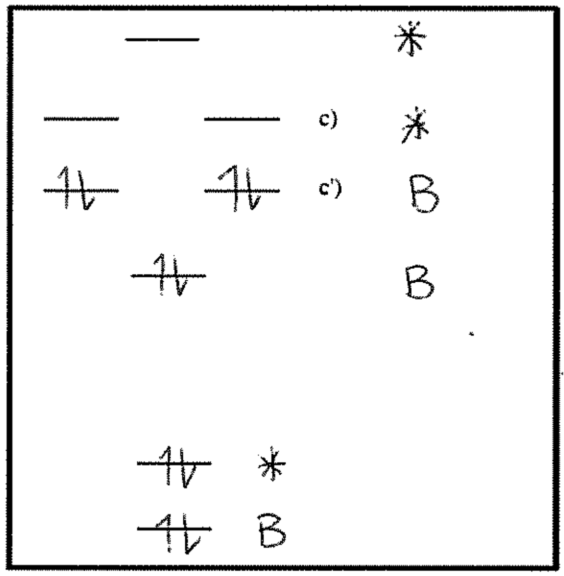
**12. (: _ points)** The molecule CO (carbon monoxide) is formed in the partial oxidation of gasoline in car engines, and further oxidizes to $CO_2$. It is odorless, colorless, and extremely toxic because it binds irreversibly to hemoglobin in the blood, leading to asphyxiation. Assume




(a) Fill the molecular orbital diagram in the box with the correct number of electrons for CO.

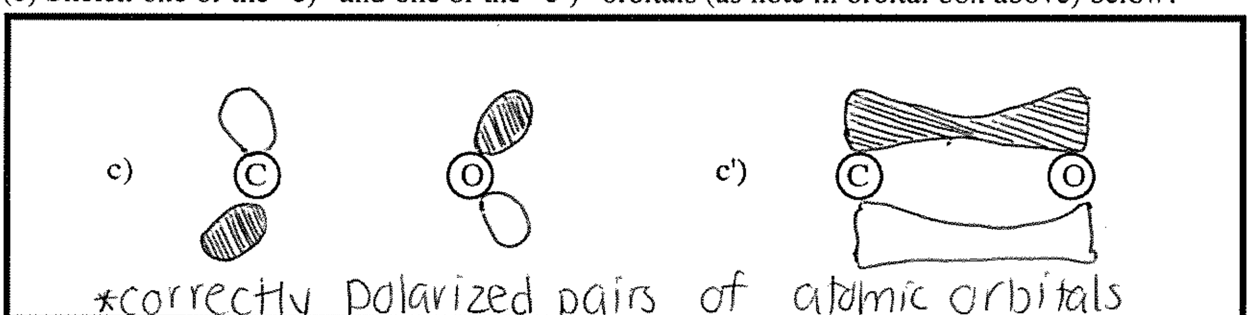
C = 4 electrons

O = 6 electrons




(b) Label each orbital in the above box as either "B" for bonding or "*" for antibonding.

(c) Sketch one of the "c)" and one of the "c')" orbitals (as note in orbital box above) below.




*correctly polarized pairs of atomic orbitals also OK.

(d) What will happen to liquid CO when it is poured between the poles of a magnet? Explain in 1-2 sentences.

It will not stick (diamagnetic).

(e) What is the bond order of CO?

$$BO = \frac{8-2}{2} = \frac{6}{2} = \boxed{3}$$

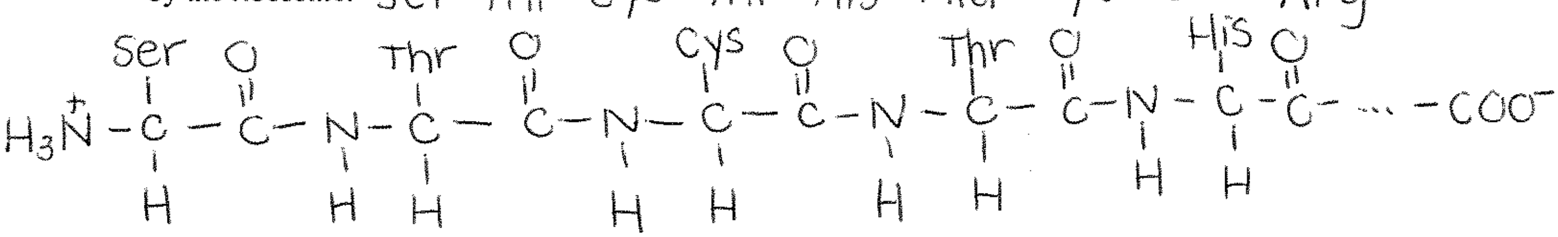
**13. (15 points)** The bases in a single strand of DNA is found to be:

3'- TCGTGCACGTGAGTGCGCTTTCTCGCA-5'

(a) Write the base sequence for the complimentary strand of m-RNA (denote which end is the 5' and 3' ends of your base sequence).

5'-AGC ACG UGC ACU CAC GCG
AAA GAG CGU-3'

(b) Draw the structure of the peptide coded by the m-RNA. Label the side chains with the three letter amino acid code (you do not need to draw them). Order your polypeptide chain as it would be read by the ribosome. Ser-Thr-Cys-Thr-His- Ala-Lys-Glu-Arg

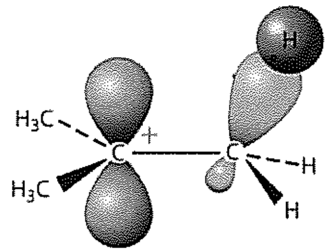


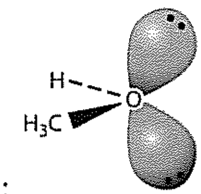
(c) Would this peptide be more soluble in water or hexane? Explain.

Water

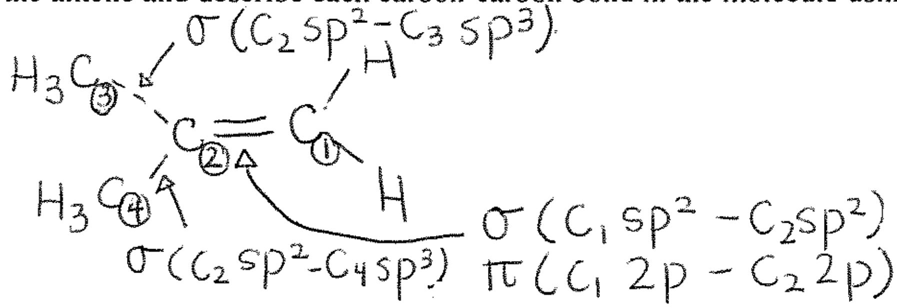
because "like dissolve like". The polypeptide chain is made of polar side chains.

**14. (10 points)** The synthesis of alkenes can be completed by an elimination mechanism. The second step in the mechanism of this reaction involves the extraction of a hydrogen from the carbocation (pictured below, on left) by a nucleophile (pictured below, on right) to create the alkene $(CH_3)_2CCH_2$.

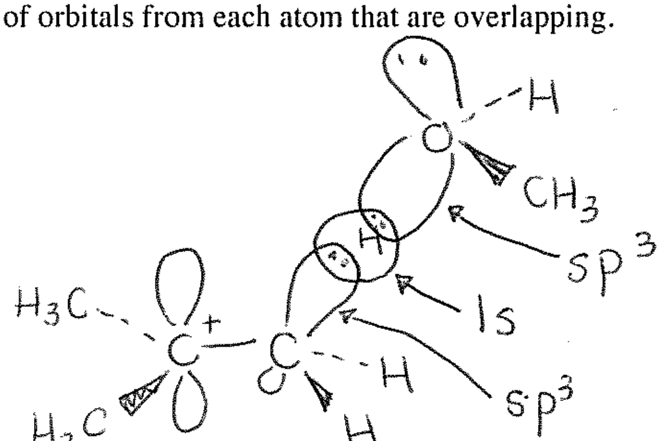
Carbocation: 


Nucleophile: 


(a) Draw the alkene and describe each carbon-carbon bond in the molecule using hybrid orbitals.




(b) Sketch the orbital overlap of the activated complex (the overlap of the two species above) and label the type of orbitals from each atom that are overlapping.



**15. (4 points each) True/False. Confirm whether each statement below is true or false. Explain your reasoning for each question in full sentences for full credit. Diagrams and/or figures are also valid and sometimes very useful for full explanations, but not required.**

(a) In the localized electron model, a double bond between two atoms is always made of 1 pi bond, which is formed by hybrid orbitals and located along the center-line between two atoms.

False. Pi bonds are made from unfilled/unhybridized p orbitals and this bond is located above and below the σ bond axis.

(b) When either mixing orbitals in the localized electron or molecular orbital models orbital are always conserved.

True. The # of orbitals you put must equal the # you get out. This is true for either model.

(c) For a diatomic molecule the higher the bond order the weaker the bond between the two atoms.

False. Bond order directly relates to bond strength. Thus the higher the bond order the stronger the chemical bond.

(d) Nuclear magnetic resonance spectroscopy can tell you about the connectivity and types of hydrogens that are in a molecule.

True. This information comes from the multiplicity and chemical shifts obtained from the spectra.

(e) Carbon is both the hardest and softest element.

True:

Hardest= Diamond

Softest= Graphite (sheets of C shift + slide across each other)

**16. (4 points each) Short Answer. Use complete sentences in your explanations for full credit.**

(a) Name four types of intermolecular interactions that stabilize tertiary protein structures.

(1) Covalent bond/ Disulfide bond
(2) London dispersion
(3) Ionic bonding
(4) Hydrogen bonding
(5) Dipole-dipole interaction

(b) Why do we use codons that are 3 bases long rather than codons that are 2 bases in length?

Because we need to code for 20 amino acids. And 3 codon base with 4 different bases gives us $4^3$ or 64 different options. However if we had 2 then $4^2$ is 8 which is not enough to code for all 20 AAs.

(c) What are you describing when you describe the quaternary structure of a protein?

A protein complex or how several monomers of a protein come together in a large protein complex/aggregate.

(d) Describe what type of orbitals are involved in making a triple bond in the localized electron model (hybrid orbitals).

Triple bond = 1 σ bond between hybrid orbitals (usually sp orbitals)

2 π bonds, which are perpendicular to eachother formed from p orbitals above + below the plane of the σ bond.

(e) List four difference between DNA and m-RNA.

| DNA | RNA |
| --- | --- |
| -Double stranded | -Single stranded |
| - Bases= A, T, G, C | - Bases= A, U, G, C |
| -Self-replicating | -Not self-replicating |
| -Sugar= deoxyribose | -Sugar= ribose |
| -Very long (billions bp) | - smaller (100s-1000s bp) |
| -contains many genes | - 1 mRNA per gene |