Exam I
23 January 2004

Name: ___________________________________________

• This exam contains 5 pages of questions – confirm this once you begin.
• You will have 70 minutes
• An abbreviated Periodic Table can be found on the last page.
• No calculators or models are permitted.
• Read all questions carefully – answer the question that is asked!
• Illegible or indecipherable answers may not receive potential partial credit.
• Good luck!

1. (6 pts) Draw the Lewis structure for the compounds below. Be certain to show all lone pairs and formal charges. Your final structure must be in the box provided.

   a) NaCN

   b) CH$_3$NNH

2. (10 pts) Name or draw the following compounds, adhering to IUPAC nomenclature rules.

   2-methylpentane

   2,3-dimethyl-4-propyl-octane

   1,1,4-trimethylcyclooctane

   4-(1-methylethyl)decane
3. (8 pts) Identify which of the following compounds (A - F)...

a) are the same compound? __A__ = __F__

\[ \text{A} \quad \text{B} \quad \text{C} \]
\[ \text{D} \quad \text{E} \quad \text{F} \]

b) are cis-trans isomers? __A__ (or __F__) + __D__

\[ \text{A} \quad \text{B} \quad \text{C} \]
\[ \text{D} \quad \text{E} \quad \text{F} \]

c) are constitutional isomers? __A__ (or __F__) + __C__

OR __A__ (or __F__) + __E__ OR __C__ + __E__

\[ \text{A} \quad \text{B} \quad \text{C} \]
\[ \text{D} \quad \text{E} \quad \text{F} \]

d) have no isomeric relationship? __B__ + __any__

(B has a molecular formula of C₈H₁₆, whereas all of the other compounds are C₇H₁₄.)

4. (6 pts) Identify each of the following alkenes as cis, trans, or neither.

\[ \text{A} \quad \text{B} \quad \text{C} \]
\[ \text{D} \quad \text{E} \quad \text{F} \]

5. (10 pts) Which of the electronic configurations shown below...

a) violates Hund’s rule? __B__

\[ \text{A} \quad \text{B} \quad \text{C} \quad \text{D} \]

If equal energy orbitals are available, don’t pair e’s

b) violates the Aufbau principle? __A__

“Build up” by adding e’s from bottom to top

\[ \text{A} \quad \text{B} \quad \text{C} \quad \text{D} \]

c) violates the Pauli exclusion principle? __C__

2e’s max per orbital; must have different spins

\[ \text{A} \quad \text{B} \quad \text{C} \quad \text{D} \]

d) represents C in the ground state? __D__

Hund’s, Pauli’s, and the Aufbau are followed

\[ \text{A} \quad \text{B} \quad \text{C} \quad \text{D} \]

e) represents C in the excited state? __A__

An e has been promoted to a higher E orbital

\[ \text{A} \quad \text{B} \quad \text{C} \quad \text{D} \]
6. (18 pts) Taxol (paclitaxel) is an antitumor agent that was first isolated from the bark of the yew tree in 1971. Arguably the greatest bio-prospected success ever, it is FDA approved for the treatment of many ovarian, breast, Kaposi’s sarcoma, and lung cancers.

\[ \text{\begin{tikzpicture} \end{tikzpicture}} \]

a) In the boxes provided indicate the hybridization of the specified atoms.

b) Identify one of each of the following functional groups in taxol by circling and clearly labeling them in the structure above. If a functional group listed is not present then write “None” next to it.

- Aldehyde: None
- Aromatic
- Halide: None
- Alkene
- Carboxylic acid: None
- Ketone
- Amide
- Ester
- Alcohol
- Amine: None
- Ether
- Thiol: None

c) If you identified an amide or amine indicate (circle) whether it is primary, secondary, or tertiary.

\[ \text{1}^\circ \quad 2^\circ \quad 3^\circ \]

d) If you identified a halide or alcohol indicate (circle) whether the one you selected is primary, secondary, or tertiary.

\[ \text{1}^\circ \quad 2^\circ \quad \text{OR} \quad 3^\circ \]
7. (18 pts) Clearly circle the correct answer for the following questions. There is only one correct answer for each; no credit will be given if more than one answer is circled for each question.

a) Which compound has the lowest boiling point?

b) Which compound has the highest boiling point?

c) Identify the Lewis acid from among the following compounds.

\[ \text{PCl}_3 \hspace{1cm} \text{BCl}_3 \hspace{1cm} \text{CH}_3\text{NH}_2 \]

d) Which of the following compounds is the weakest acid?

\[ \text{HF} \hspace{1cm} \text{H}_3\text{O}^+ \hspace{1cm} \text{H}_2\text{O} \hspace{1cm} \text{H}_2\text{S} \]

e) Provide curved arrow notation for the following reaction step (hint: you might need to draw lone pairs):

f) The electron density of a \( \pi \)-bond is located _________ the internuclear axis.

above and below  along  \(120^\circ\)  to

g) Which of the following best describes the bonding scheme for the indicated bond?

\[ \text{sp}-\text{sp}^3 \hspace{1cm} \text{sp}^2-\text{sp}^2 \hspace{1cm} \text{sp}-\text{sp}^3 \]

h) Above each of the following compounds, draw the conventional dipole moment arrow to indicate the bond polarity for the bond shown.

i) What is the dominant intermolecular force for \( \text{Cl}_2 \)?

\[ \text{London} \hspace{1cm} \text{H-bonding} \hspace{1cm} \text{ionic} \hspace{1cm} \text{dipole-dipole} \]
8. (6 pts) Answer the questions that follow for acetonitrile (CH₃CN)
   - What is the hybridization for C1? \( sp \)
   - What is the C2-C1-N bond angle? \( 180^\circ \)
   - How many total electrons are involved in pi bonds in acetonitrile? 4

9. (10 pts) Draw an MO bonding picture for acetonitrile independently showing the \( \sigma \)-framework and the \( \pi \)-framework.

\[ \text{\( \sigma \)-framework:} \]
\[ \text{\( \pi \)-framework:} \]

10. (8 pts) Follow the instructions that follow for the reaction between propyne and hydroxide.
    (Hint: the acidic proton on propyne is explicitly shown.)
   a) Write an equation for the following acid-base reaction.
   b) Label the acid (A), base (B), conjugate acid (CA), and conjugate base (CB).
   c) Predict whether the equilibrium favors the reactants or products.
   d) Write the \( K_{eq} \) value above the equilibrium arrows.

\[ \text{A} \quad \text{B} \quad \text{CB} \quad \text{CA} \]
\[ \equiv \text{H} + \ominus \text{OH} \quad \text{K}_a = 10^{-9.3} \quad \ominus \quad \equiv \text{H} + \text{H}_2\text{O} \]
\[ \text{pK}_a \quad 25 \quad \text{pK}_a \quad 15.7 \]

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