DO NOT OPEN THE EXAM UNTIL THE PROCTOR TELLS YOU TO DO SO

Instructions:

1. Fill in the bubble sheet with your name (last name first), ID number, and test version. (This is version A). Use a soft lead pencil to do this. This information must be entered correctly, or your test will not be scored properly.

2. Write the special code that is printed on your bubble sheet here: my code for Exam 2 is ___________. This is a unique code for your test. Test results will be posted by this number only on the class web page.

3. There are 20 multiple choice questions. Mark the letter (a-e) on your answer bubble sheet of the one choice that best answers the question. There is no partial credit, and you need not show your work. Use scratch paper or the backs of the exam pages if you need space to work.

4. You are permitted to have one 8.5” × 11” sheet of paper containing any information you wish written or printed on both sides. There is a periodic table attached to the back of the exam.

5. You must remain seated until the exam is officially over. All answer sheets will be collected at the same time. Hand in the answer sheet only. Keep your copy of the exam for self-scoring and review.

6. The answer key will be available on the class home page (http://www.chem.umn.edu/class/1021/robert00) by tomorrow afternoon. Test results will be posted on the class web page by next Monday afternoon.

Some important constants and equations that you may need:

\[
\begin{align*}
R &= 8.314 \text{ J} / \text{mol} \cdot \text{K} = 0.08206 \text{ L} \cdot \text{atm} / \text{mol} \cdot \text{K} \\
h &= 6.626 \times 10^{-34} \text{ J} \cdot \text{s}^{-1} \\
c &= 3.00 \times 10^8 \text{ m} \cdot \text{s}^{-1} \\
1 \text{ nm} &= 10^{-9} \text{ m} \\
1 \text{ ml} &= 1 \text{ cm}^3 = 10^{-3} \text{ L} \\
K &= ^\circ \text{C} + 273.15
\end{align*}
\]
1. Which of the following pairs is isoelectronic?
   (a) Li$^+$ and K$^+$
   (b) Na$^+$ and Ne
   (c) I$^-$ and Cl$^-$
   (d) S$^{2-}$ and Ne
   (e) Al$^{3+}$ and B$^{3+}$

2. Select the best Lewis structure for acetone, CH$_3$COCH$_3$.

(a) \[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{C} \quad \text{C} \quad \text{C} \quad \text{O} \quad \text{C} \quad \text{H} \\
\text{H} \\
\text{H}
\end{array}
\]

(b) \[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{C} \quad \text{C} \quad \text{C} \quad \text{H} \\
\text{H} \\
\text{H}
\end{array}
\]

(c) \[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{C} \quad \text{C} \quad \text{O} \quad \text{H} \\
\text{H} \\
\text{H}
\end{array}
\]

(d) \[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{C} \quad \text{C} \quad \text{C} \quad \text{O} \\
\text{H} \\
\text{H}
\end{array}
\]

(e) \[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{C} \quad \text{C} \quad \text{C} \quad \text{O} \\
\text{H} \\
\text{H}
\end{array}
\]
3. Which of the following trends are correct for alkanes of increasing molecular mass?
   (a) melting point increases, boiling point increases, number of structural isomers increases
   (b) melting point increases, boiling point decreases, number of structural isomers increases
   (c) melting point decreases, boiling point increases, number of structural isomers increases
   (d) melting point decreases, boiling point increases, number of structural isomers decreases
   (e) melting point decreases, boiling point decreases, number of structural isomers increases

4. How many of the following molecules and ions are linear?
   \[ \text{NH}_3 \quad \text{NH}_4^+ \quad \text{HCN} \quad \text{CO}_2 \quad \text{NO}_2 \]
   (a) 0
   (b) 1
   (c) 2
   (d) 3
   (e) 4

5. The bond angles about the carbon atom in the formaldehyde molecule, H_2C=O, are approximately:
   (a) 120°
   (b) 60°
   (c) 109°
   (d) 180°
   (e) 90°
6. The hybridization of phosphorous in the cation \( \text{PH}_2^+ \) is:
   (a) \( \text{sp}^2 \)
   (b) \( \text{sp}^3 \)
   (c) \( \text{dsp} \)
   (d) \( \text{sp} \)
   (e) None of these answers is correct.

7. What is a possible product of the reaction that results when a mixture of butane and \( \text{Cl}_2 \) are exposed to ultraviolet radiation?
   (a) \( \text{C}_4\text{H}_9\text{Cl} \)
   (b) \( \text{C}_4\text{H}_8\text{Cl} \)
   (c) \( \text{C}_4\text{H}_{10}\text{Cl} \)
   (d) \( \text{C}_4\text{H}_6\text{Cl}_2 \)
   (e) \( \text{C}_4\text{H}_9\text{Cl}_2 \)

8. Consider the following Lewis structure:

\[
\begin{array}{c}
\text{H} \\
\text{O} \\
\text{C} \\
\text{C} \\
\text{H} \\
\end{array}
\]

Which statement about the molecule is false?
   (a) There are 10 sigma and 2 pi bonds.
   (b) C-2 is \( \text{sp}^2 \)-hybridized with bond angles of approximately 120º.
   (c) Oxygen is \( \text{sp}^3 \)-hybridized.
   (d) This molecule contains 28 valence electrons.
   (e) Some of the H-C-H bond angles are approximately 109º.
9. Name the following compound:

\[
\begin{align*}
&\text{CH}_3 \\
&\text{CH}_3 - \text{CH} - \text{C} - \text{CH}_3 \\
&\text{CH}_2\text{CH}_3
\end{align*}
\]

(a) \textit{n}-heptane \\
(b) 2-methyl-2-ethylbutane \\
(c) 3,3-dimethylpentane \\
(d) 2,2-diethylpropane \\

10. How many stable isomers are there with the molecular formula \( \text{C}_3\text{H}_5\text{Br} \)? Include both structural and geometrical isomers.

(a) 2 \\
(b) 3 \\
(c) 4 \\
(d) 5 \\
(e) 6
11. Which structure represents an optically active compound in which at least one atom is sp\(^2\) hybridized?

(a) \(\text{CH}_3\text{CH}_2\text{C}--\text{OH}\)

(b) \(\text{CH}_3\text{CH}_2\text{C}--\text{CHO}\)

(c) \(\text{CH}_3\text{CH}--\text{C}--\text{CH}_3\)

(d) \(\text{CH}_3\text{CH}_2\text{C}--\text{NH}_2\)

(e) \(\text{CH}_3\text{C}--\text{CH}_2--\text{CHO}\)

12. The hybridization of the central nitrogen atom in N\(_2\)O is:

(a) sp.

(b) sp\(^2\).

(c) sp\(^3\).

(d) dsp\(^3\).

(e) The central nitrogen atom is not hybridized.
13. Given the following information:

\[ \text{N}_2 \text{ bond energy} = 941 \text{ kJ} \cdot \text{mol}^{-1} \]
\[ \text{F}_2 \text{ bond energy} = 154 \text{ kJ} \cdot \text{mol}^{-1} \]

\[ \frac{1}{2} \text{N}_2(g) + \frac{3}{2} \text{F}_2(g) \rightarrow \text{NF}_3(g) \quad \Delta H^\circ = -103 \text{ kJ} \cdot \text{mol}^{-1} \]

Calculate the average N-F bond energy.

(a) 113 kJ·mol⁻¹
(b) 268 kJ·mol⁻¹
(c) 317 kJ·mol⁻¹
(d) 66 kJ·mol⁻¹
(e) none of these

14. Which of the following has the smallest ionic radius?

(a) Ca²⁺
(b) Cl⁻
(c) Li⁺
(d) O²⁻
(e) Be²⁺

15. Which of the following compounds has the largest lattice energy, i.e. the lattice energy most favorable to a stable lattice?

(a) CsI
(b) LiI
(c) LiF
(d) CsF
(e) MgO
16. Choose the statement that best describes the PbCl₄ molecule in the gas phase.
   
   (a) The bond angles are all about 109º.
   (b) The molecule is polar.
   (c) The molecule has a dipole moment.
   (d) The Pb-Cl bonds are non-polar.
   (e) All of the above statements a-d are correct.

17. Which of the following species is best described by two or more resonance structures?
   
   (a) PH₃
   (b) NH₄⁺
   (c) O₃
   (d) SO₃
   (e) HCN

18. Substances with the same molecular formula but with different structures are known as:
   
   (a) polymers.
   (b) esters.
   (c) isomers.
   (d) isotopes.

19. In chemical reactions involving alkenes and alkynes, pi bonds can be broken and replaced with sigma bonds. These reactions are called
   
   (a) combustion reactions.
   (b) dehydrogenation reactions.
   (c) substitution reactions.
   (d) hydrogen reactions.
   (e) addition reactions.
20. Which of the following compounds contains only one unshared pair of electrons?

(a) NH$_3$
(b) H$_2$O
(c) CH$_4$
(d) NaCl
(e) BF$_3$
ANSWER KEY FOR EXAM 3, VERSION A

1. (b)  
2. (b)  
3. (a)  
4. (c)  
5. (a)  
6. (a)  
7. (a)  
8. (c)  
9. (c)  
10. (d)  
11. (b)  
12. (a)  
13. (b)  
14. (e)  
15. (e)  
16. (a)  
17. (c)  
18. (c)  
19. (e)  
20. (a)