Exam 4  
CEM 151  
Wednesday, December 5, 2012

(Multiple choice, 5 points)
1. How many unhybridized p atomic orbitals (add up the orbitals on all the atoms) are involved in $\pi$ bonding in 1,3-butadiene according to Valence Bond Theory?
   a. 0  
   b. 1  
   c. 2  
   d. 3  
   e. 4  
   f. 5  
   g. 6  
   h. 7  
   i. 8
   j. None of the above

2. According to molecular orbital theory, which of the following will form a stable molecule?
   a. $He_2$  
   b. $F_2$  
   c. $H_2$  
   d. $H_2^-$  
   e. $O_2^-$  
   f. $He_2^-$  
   g. c, e and f
   h. c and f
   i. All of the above
   j. None of the above

3. Based on molecular orbital theory, the bond order of the F–F bond in the $F_2^+$ ion is
   a. 0  
   b. 0.5  
   c. 1  
   d. 1.5  
   e. 2  
   f. 2.5  
   g. 3  
   h. 3.5  
   i. None of the above  
   j. Cannot determine

4. Is the molecule drawn below planar or non-planar? What is the hybridization of each of the carbon atoms in allene (in numerical order, the carbons are numbered below)?
   a. planar, $sp^2$, $sp^2$, $sp^2$, $sp^2$  
   b. planar $sp^2$, $sp^2$, $sp^2$, $sp^2$  
   c. planar, $sp^2$, $sp^2$, $sp^2$, $sp^2$  
   d. nonplanar, $sp^2$, $sp^2$, $sp^2$, $sp^2$  
   e. nonplanar, $sp^2$, $sp^2$, $sp^2$, $sp^2$  
   f. nonplanar, $sp^2$, $sp^2$, $sp^2$, $sp^2$
   g. nonplanar, $sp^2$, $sp^2$, $sp^2$, $sp^2$
   h. nonplanar, $sp^2$, $sp^2$, $sp^2$, $sp^2$
   i. None of the above

5) A substance with unpaired electrons will be
   a. slightly attracted to a magnet.
   b. slightly repelled by a magnet.
   c. permanently magnetic.
   d. brightly colored.
   e. nonmetallic.

6) The coordination number of cobalt in $CoCl_3 \cdot 6NH_3$ is
   a. 2  
   b. 3  
   c. 4  
   d. 5  
   e. 6  
   f. 7  
   g. 8  
   h. 9

7) Does either or both cis- or trans-$[Mn(en)_2Br_2]$ have optical isomers?
   a. cis only  
   b. trans only  
   c. both cis and trans  
   d. neither cis nor trans  
   e. It does not exhibit cis-trans isomerism  
   f. They are all optically active

8) Based on electron configuration, which is most likely colorless?
   a. $[Cu(NH_3)_4]^{2+}$  
   b. $[Cd(NH_3)_4]^{2+}$  
   c. $[Cr(NH_3)_5Cl]^{2+}$  
   d. $[Co(NH_3)_6]^{2+}$  
   e. $[Ni(NH_3)_6]^{2+}$  
   f. They are all colored
Use the color wheel below to answer the next 2 questions. The letters stand for colors, r, red, o, orange, y, yellow, g, green, b, blue, v, violet.

9) A complex that absorbs light at 700 nm will appear __________.
   a. red c. yellow e. violet g. white
   b. green d. orange f. black h. it is colorless

10) A metal complex absorbs light mainly at 420 nm. What is the color of the complex?
    a. green c. red e. purple g. white
    b. orange d. yellow f. black h. it is colorless

11) Based on the crystal-field strengths F^- < CH2CN < NH3 < NO2^- < CN^-, which Co(III) complex is most likely high-spin?
    a. [Co(NH3)6]^{3+} c. [Co(CN)6]^{3-} e. [Co(CH3CN)6]^{3+}
    b. [Co(NO2)6]^{3-} d. [CoF6]^{3-}

12) The correct name for [Ni(NH3)6](NO3)3 is __________.
    a. dinitrohexaamminenickel (II)
    b. hexaamminenickel (III) trinitrate
    c. nitrohexaamminenickelate (III)
    d. trinitrohexaamminenickel (III)
    e. hexamminetritronickel (III)
    f. hexaamminenickel (II) nitrate
    g. hexaamminenickel (III) nitrate

13) What is the oxidation number of Ni in [Ni(CN)5]^{3-}?
    a. +1 c. +3 e. +5 g. -1 i. -3
    b. +2 d. +4 f. +6 h. -2 j. None of the above

14) Which one of the following complex ions will be paramagnetic?
    a. [Fe(H2O)6]^{2+} (low spin) c. [Co(H2O)6]^{3+} (low spin) e. [Zn(NH3)4]^{2+} (tetrahedral)
    b. [Fe(H2O)6]^{3+} (low spin) d. [Zn(H2O)4]^{2+} (tetrahedral)

**Directions for the next 2 problems.** Give the number of unpaired electrons for the following compounds:
15. \([\text{Cr}(\text{H}_2\text{O})_6]^{3+}\) (high spin)
   a. 0  c. 2  e. 4  g. 6  i. Can’t tell
   b. 1  d. 3  f. 5  h. 7  j. None of the above

16. \([\text{Rh}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}\) (low spin)
   a. 0  c. 2  e. 4  g. 6  i. Can’t tell
   b. 1  d. 3  f. 5  h. 7  j. None of the above

17. How many isomers does 1-butene have?
   a. 2  c. 4  e. 6  g. 8
   b. 3  d. 5  f. 7  h. 9

18. The structure of 2,3-dimethylheptane is ________.

A) 
\[
\begin{array}{c}
\text{CH}_3 \\
\mid \\
\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2
\end{array}
\]

B) 
\[
\begin{array}{c}
\text{H}_3\text{C} \\
\mid \\
\text{CH}_3\text{CH}_2\text{C}\text{CH}_3
\end{array}
\]

C) 
\[
\begin{array}{c}
\text{H}_3\text{C} \\
\mid \\
\text{CH}_2\text{C}\text{CH}_2
\end{array}
\]

D) 
\[
\begin{array}{c}
\text{CH}_3 \\
\mid \\
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2
\end{array}
\]

E) 
\[
\begin{array}{c}
\text{CH}_3 \\
\mid \\
\text{H}_3\text{C} \text{CH}_3
\end{array}
\]
19. Which of the following are aromatic?

a. 

b. 

c. 

d. 

e. 

f. b, c and e

g. a and d

h. a, b and d

i. b and e

j. None of the above
(essay/short answer, 15 points)
20. Draw the molecular orbitals for CN$^-$ in order of energy and fill them with the appropriate number of electrons. What is the bond order for CN$^-$ according to your diagram? Is CN$^-$ diamagnetic or paramagnetic? Explain using your diagram. Which do you predict would be more stable CN$^-$ or SiP$^-$ and why? (you don’t need more than 10 words to answer).
21. (15 points) Sketch all possible isomers of:
(a) Square planar \([\text{Pt(NH}_3\text{)}_2\text{Cl}_2]\)

(b) Octahedral \([\text{CoBrCl(en)}_2^-]\) (where en is \(\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2\))

(c) Tetrahedral \([\text{Fe(NH}_3\text{)}\text{ClBrF}]\)