Chem 152 Midterm II

Section:______________  Name:_________________

You will have 50 minutes. Useful equations and other information is provided on the last page of this exam...feel free to remove this page if it is convenient. You do not need to turn it in with the exam.

Question 1________________/40
Question 2________________/10
Question 3________________/20
Question 4________________/10
Question 5________________/20

Total____________________/100

Version C
1. Multiple Choice (4 pts. each): Bold indicates the correct answer.

a. For an electrochemical cell to be galvanic, what must be true:

   A. $E_{\text{cell}} < 0$       B. $\Delta G < 0$       C. $K=1$       D. $n = 2$

b. Which of the following is true about the ionization energy of Mg$^{+}$?

   A: It will be equal to the ionization energy of Li.
   B: It will be equal to and opposite in sign to the electron affinity of Mg.
   C: It will be equal to and opposite in sign to the electron affinity of Mg$^{+}$.
   D: It will be equal to an opposite in sign to the electron affinity of Mg$^{+2}$.

c. The electron configuration $1s^22s^22p^63s^23p^64s^23d^5$ corresponds to:

   A: Tc       B: Mn       C: Fe       D: Cr

d. Which species has the greatest electron affinity:

   A: Na       B: N       C: Li       D: F

e. The workfunction of Nb is $6.67 \times 10^{-19}$ J. This corresponds to which of the following wavelengths:

   A. 459 nm       B. 287 nm       C. 298 nm       D. 320 nm
Multiple choice (cont.)

f. No currently known element contains electrons in “g orbitals,” but we may find such elements one day. How many electrons can be incorporated into a set of g orbitals:

A: 10  B: 14  C: 18  D: 20

g. Which of the following is not an allowed set of quantum numbers for the H atom (given in the form \{n, l, m_l\}):  

A: \{3, 1, 1\}  B: \{2, 0, 0\}  C: \{0, 0, 1\}  D: \{1, 1, 0\}

h. Consider the following reduction:

\[ \text{Zn}^{2+} (aq) + 2e^- \rightarrow \text{Zn} (s) \]

The orbital configurations consistent with this reduction are:

A: \text{Zn}^{2+} (1s^22s^22p^63s^23p^63d^{10}) \rightarrow \text{Zn} (1s^22s^22p^63s^23p^64s^23d^{10})
B: \text{Zn}^{2+} (1s^22s^22p^63s^23p^63d^9) \rightarrow \text{Zn} (1s^22s^22p^63s^23p^64s^23d^9)
C: \text{Zn}^{2+} (1s^22s^22p^63s^23p^63d^{10}) \rightarrow \text{Zn} (1s^22s^22p^63s^23p^64s^23d^8)
D: \text{Zn}^{2+} (1s^22s^22p^63s^23p^63d^{10}) \rightarrow \text{Zn} (1s^22s^22p^63s^23p^64s^13d^{10})

j. If \(n = 3\) and \(l = 2\), how many \(m_l\) levels are there:

A: 1  B: 3  C: 5  D: 10

k. Sodium losing an electron is a __________ process, and fluorine losing an electron is a __________ process.

A: endothermic, exothermic  B: endothermic, endothermic  C: exothermic, endothermic  D: exothermic, exothermic
Section II: Long-Answer/Numerical Questions

2a. (4 pts). Circle the species being reduced in the following reactions:

\[
Pb^{2+}(aq) + 2Cr^{2+}(aq) \rightarrow Pb(s) + 2Cr^{3+}(aq)
\]

\[
14H_3O^+(aq) + 6I^-(aq) + Cr_2O_7^{2-}(aq) \rightarrow 2Cr^{3+}(aq) + 3I_2(s) + 21H_2O(l)
\]

2b. (6 pts.) Write down the expected electron configuration for the following:

Y:

Pt:

Se^{2+}:
3a. (10 pts.) Balance the redox reaction corresponding to the following electrochemical cell:

$$N_2O_4 | NO_3^- | Zn^{2+} | Zn$$
3b. (10 pts) Determine $E_{\text{cell}}^\circ$ and $K$ for the electrochemical cell provided in part a of this question.
4 (10 pts.) What wavelength of light corresponds to electron relaxation from \( n = 4 \) to \( n = 1 \) in \( \text{Li}^{+2} \)?
5a. (6 pts.) The species sodide (Na⁻) is produced in the following equilibria:

\[ \text{Na}^- \rightleftharpoons \text{Na}^+ + \text{Na}^- \]

Balance the above redox reaction.
5b. (14 pts.) “The Prickly Cactus Special”

If we put a chunk of solid Na into solution, the concentration of Na⁺ at equilibrium is found to be 0.001 M. Determine the standard half-cell potential for the reduction of Na.

\[
K = \left[ Na^+ \right] \left[ Na^- \right] = \left[ Na^- \right]^2 = 10^{-6}
\]
**Standard Electrode (Half-Cell) Potentials (298 K)**

<table>
<thead>
<tr>
<th>Skeletal Half Reaction (as Reduction)*</th>
<th>$E^\circ$ (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co$^{+3}$ (aq)/Co$^{+2}$ (aq)</td>
<td>+1.82</td>
</tr>
<tr>
<td>Au$^{+3}$ (aq)/Au(s)</td>
<td>+1.50</td>
</tr>
<tr>
<td>O$_2$(g)/H$_2$O(l)</td>
<td>+1.23</td>
</tr>
<tr>
<td>Br$_2$ (l)/2Br$^-$ (aq)</td>
<td>+1.07</td>
</tr>
<tr>
<td>NO$_3^-$ (aq)/NO (g)</td>
<td>+0.96</td>
</tr>
<tr>
<td>NO$_3^-$ (aq)/N$_2$O$_4$ (g)</td>
<td>+0.83</td>
</tr>
<tr>
<td>Ag$^+$ (ag)/Ag (s)</td>
<td>+0.80</td>
</tr>
<tr>
<td>O$_2$(g)/OH$^-$ (aq)</td>
<td>+0.40</td>
</tr>
<tr>
<td>Cu$^{+2}$ (aq)/Cu (s)</td>
<td>+0.34</td>
</tr>
<tr>
<td>2H$^+$ (aq)/H$_2$ (g)</td>
<td>0.00</td>
</tr>
<tr>
<td>Sn$^{+2}$ (aq)/Sn (s)</td>
<td>-0.14</td>
</tr>
<tr>
<td>Cd$^{+2}$ (aq)/Cd (s)</td>
<td>-0.40</td>
</tr>
<tr>
<td>Fe$^{+2}$ (aq)/Fe (s)</td>
<td>-0.44</td>
</tr>
<tr>
<td>Cr$^{+3}$ (aq)/Cr (s)</td>
<td>-0.74</td>
</tr>
<tr>
<td>Zn$^{+2}$ (aq)/Zn (s)</td>
<td>-0.76</td>
</tr>
<tr>
<td>Mg$^{+2}$ (aq)/Mg (s)</td>
<td>-1.18</td>
</tr>
<tr>
<td>Na$^+$ (aq)/Na (s)</td>
<td>-2.71</td>
</tr>
</tbody>
</table>

*All reactions are written as reductions. Water/H$^+$/OH$^-$/e$^- \text{ needed to create a balanced half-cell reaction are suppressed.}
Useful Information

Constants: \( h = 6.626 \times 10^{-34} \text{ J.s} \)
\( c = 3 \times 10^8 \text{ m/s} \)
\( F = 96,485 \text{ C/mol e-} \)
\( \text{e- charge} = 1.6 \times 10^{-19} \text{ C} \)
\( \text{e- mass} = 9.1 \times 10^{-31} \text{ kg} \)
\( R = 8.314 \text{ J/mol.K} = 0.0821 \text{ l.atm/mol.K} \)
\( 1 \text{ nm} = 10^{-9} \text{ m} \)

\[ E = \sqrt{2.178 \times 10^{18} \frac{Z^2}{n^2}} \quad E = \frac{n^2 h^2}{8 m L^2} \quad E = \frac{h}{\ell} = \frac{hc}{\ell} \]

\[ \Delta G^\circ = n F E_{cell}^o = RT \ln K \]
\[ E_{cell} = E_{cell}^o \frac{0.0591 V}{n} \log(Q) \]

\[ \Delta G = \Delta G^\circ + RT \ln(Q) \]

\[ aA + bB \rightarrow cC + dD \]

\[ K = \frac{[C]^c[D]^d}{[A]^a[B]^b} \]

\[ V(r) = \frac{Ze(e)}{r} \]

\[ x \cdot p = \frac{h}{4\ell} \]

For H-atom like wavefunctions:

\( n = 1, 2, ..., 1 = (n-1), (n-2), ... 0, \quad m_i = -l......0......l, \quad m_s = \pm 1/2 \)