DO NOT OPEN THIS EXAM UNTIL INSTRUCTED.
CALCULATORS ARE NOT TO BE SHARED.

Test Form 1

Instructions: You should have with you several number two pencils, an eraser, your 3" x 5" note card, a calculator, and your University ID Card. If you have notes with you, place them in a sealed backpack and place the backpack OUT OF SIGHT or place the notes directly on the table at the front of the room.

Fill in the front page of the Scantron answer sheet with your test form number (listed above), last name, first name, middle initial, and student identification number. **Leave the class section number blank.**

This exam consists of 25 multiple-choice questions. Each question has four points associated with it. Select the best multiple-choice answer by filling in the corresponding circle on the rear page of the answer sheet. If you have any questions before the exam, please ask. If you have any questions during the exam, please ask the proctor. Open and start this exam when instructed. When finished, place your Scantron form in the appropriate stack. You may keep the exam packet, so please show your work and mark the answers you selected on it.
Spectrochemical series: CN\textsuperscript{−} > NO\textsubscript{2}\textsuperscript{−} > en > NH\textsubscript{3} > NCS\textsuperscript{−} > H\textsubscript{2}O > F\textsuperscript{−} > Cl\textsuperscript{−}

F = 96,485 C/mole e\textsuperscript{−}

N\textsubscript{A} = 6.02 \times 10^{23}
<table>
<thead>
<tr>
<th>Acetic Acid</th>
<th>$E^\circ$, volt</th>
</tr>
</thead>
<tbody>
<tr>
<td>F$_2$(g) + 2 e$^-$ → 2F$^-$ (aq)</td>
<td>+2.866</td>
</tr>
<tr>
<td>O$_3$(g) + 2 H$^+$ (aq) + 2 e$^-$ → O$_2$(g) + H$_2$O(l)</td>
<td>+2.075</td>
</tr>
<tr>
<td>S$_2$O$_8^{2-}$ (aq) + 2 e$^-$ → 2 SO$_4^{2-}$ (aq)</td>
<td>+2.01</td>
</tr>
<tr>
<td>H$_2$O$_2$(aq) + 2H$^+$ (aq) + 2 e$^-$ → 2 H$_2$O(l)</td>
<td>+1.763</td>
</tr>
<tr>
<td>MnO$_4^-$ (aq) + 8H$^+$ (aq) + 5 e$^-$ → Mn$^{2+}$(aq) + 4 H$_2$O(l)</td>
<td>+1.51</td>
</tr>
<tr>
<td>PbO$_2$(s) + 4H$^+$ (aq) + 2 e$^-$ → Pb$^{2+}$(aq) + 2 H$_2$O(l)</td>
<td>+1.455</td>
</tr>
<tr>
<td>Cl$_2$(g) + 2 e$^-$ → 2 Cl$^-$ (aq)</td>
<td>+1.358</td>
</tr>
<tr>
<td>Cr$_2$O$_7^{2-}$ (aq) + 14 H$^+$ (aq) + 6 e$^-$ → 2 Cr$^{3+}$(aq) + 7 H$_2$O(l)</td>
<td>+1.33</td>
</tr>
<tr>
<td>MnO$_2$(s) + 4H$^+$ (aq) + 2 e$^-$ → Mn$^{2+}$(aq) + 2 H$_2$O(l)</td>
<td>+1.23</td>
</tr>
<tr>
<td>O$_2$(g) + 4H$^+$ (aq) + 4 e$^-$ → 2 H$_2$O(l)</td>
<td>+1.229</td>
</tr>
<tr>
<td>2 IO$_3^-$ (aq) + 12H$^+$ (aq) + 10 e$^-$ → I$_2$(s) + 6 H$_2$O(l)</td>
<td>+1.20</td>
</tr>
<tr>
<td>Br$_2$(l) + 2 e$^-$ → 2 Br$^-$ (aq)</td>
<td>+1.065</td>
</tr>
<tr>
<td>NO$_3^-$ (aq) + 4H$^+$ (aq) + 3 e$^-$ → NO(g) + 2 H$_2$O(l)</td>
<td>+0.956</td>
</tr>
<tr>
<td>As$^{3+}$(aq) + e$^-$ → As(s)</td>
<td>+0.800</td>
</tr>
<tr>
<td>Fe$^{3+}$(aq) + e$^-$ → Fe$^{2+}$(aq)</td>
<td>+0.771</td>
</tr>
<tr>
<td>O$_2$(g) + 2H$^+$ (aq) + 2 e$^-$ → H$_2$O$_2$(aq)</td>
<td>+0.695</td>
</tr>
<tr>
<td>I$_2$(s) + 2 e$^-$ → 2 I$^-$ (aq)</td>
<td>+0.535</td>
</tr>
<tr>
<td>Cu$^{2+}$(aq) + 2 e$^-$ → Cu(s)</td>
<td>+0.340</td>
</tr>
<tr>
<td>SO$_4^{2-}$(aq) + 4H$^+$ (aq) + 2 e$^-$ → 2 H$_2$O(l) + SO$_2$(g)</td>
<td>+0.17</td>
</tr>
<tr>
<td>Sn$^{4+}$(aq) + 2 e$^-$ → Sn$^{2+}$(aq)</td>
<td>+0.154</td>
</tr>
<tr>
<td>S(s) + 2H$^+$ (aq) + 2 e$^-$ → H$_2$S(g)</td>
<td>+0.14</td>
</tr>
<tr>
<td>2H$^+$ (aq) + 2 e$^-$ → H$_2$(g)</td>
<td>0</td>
</tr>
<tr>
<td>Pb$^{2+}$(aq) + 2 e$^-$ → Pb(s)</td>
<td>-0.125</td>
</tr>
<tr>
<td>Sn$^{2+}$(aq) + 2 e$^-$ → Sn(s)</td>
<td>-0.137</td>
</tr>
<tr>
<td>Co$^{2+}$(aq) + 2 e$^-$ → Co(s)</td>
<td>-0.277</td>
</tr>
<tr>
<td>Fe$^{2+}$(aq) + 2 e$^-$ → Fe(s)</td>
<td>-0.440</td>
</tr>
<tr>
<td>Zn$^{2+}$(aq) + 2 e$^-$ → Zn(s)</td>
<td>-0.763</td>
</tr>
<tr>
<td>Al$^{3+}$(aq) + 3 e$^-$ → Al(s)</td>
<td>-1.676</td>
</tr>
<tr>
<td>Mg$^{2+}$(aq) + 2 e$^-$ → Mg(s)</td>
<td>-2.356</td>
</tr>
<tr>
<td>Na$^+$ (aq) + e$^-$ → Na(s)</td>
<td>-2.713</td>
</tr>
<tr>
<td>Ca$^{2+}$(aq) + 2 e$^-$ → Ca(s)</td>
<td>-2.84</td>
</tr>
<tr>
<td>K$^+$(aq) + e$^-$ → K(s)</td>
<td>-2.924</td>
</tr>
<tr>
<td>Li$^+$ (aq) + e$^-$ → Li(s)</td>
<td>-3.040</td>
</tr>
<tr>
<td>Basic Solution</td>
<td></td>
</tr>
<tr>
<td>O$_3$(g) + H$_2$O(l) + 2 e$^-$ → O$_2$(g) + 2 OH$^-$ (aq)</td>
<td>+1.246</td>
</tr>
<tr>
<td>OCl$^-$ (g) + H$_2$O(l) + 2 e$^-$ → Cl$^-$ (aq) + 2 OH$^-$ (aq)</td>
<td>+0.890</td>
</tr>
<tr>
<td>O$_2$(g) + 2 H$_2$O(l) + 4 e$^-$ → 4 OH$^-$ (aq)</td>
<td>+0.401</td>
</tr>
<tr>
<td>2 H$_2$O(l) + 2 e$^-$ → H$_2$(g) + 2 OH$^-$ (aq)</td>
<td>-0.828</td>
</tr>
</tbody>
</table>
1. The oxidation number of each titanium in Na₂Ti₃O₇ is:
   (A) +4
   (B) +5
   (C) +6
   (D) +7
   (E) +10

2. Consider a "General Chemistry Battery" in which one beaker contains aqueous copper sulfate (CuSO₄) and a copper metal electrode and the other beaker contains aqueous zinc sulfate (ZnSO₄) and a zinc metal electrode.

Which of the following statements is false?
   (A) The theoretical cell voltage is 1.103 V
   (B) A salt bridge is used to allow the flow of ions but restrict the flow of electrons
   (C) The mass of the zinc electrode will decrease as the process proceeds
   (D) The concentration of Cu²⁺ (aq) increases as the process proceeds
   (E) Electrons flow from the zinc beaker to the copper beaker

3. Consider the reaction 3 Ag⁺ (aq) + Al (s) → Al³⁺ (aq) + 3 Ag (s). The oxidizing agent is:
   (A) Ag⁺ (aq)
   (B) Al (s)
   (C) Al³⁺ (aq)
   (D) Ag (s)

   Ag⁺ is oxidized; Al⁰ is the reducing agent
   Al⁰ is oxidized; Al³⁺ is the reducing agent
   Ag⁺ is reduced; Ag⁰ is the oxidizing agent
4. Consider fuel cells. Which of the following is **false**?

(A) A hydrogen fuel cell produces energy ✓
(B) The hydrogen fuel cell demonstrated in class produced water ✓
(C) The hydrogen fuel cell demonstrated in class contains platinum to facilitate the process ✓
(D) The fuel cell consists of tiny chambers that allow hydrogen gas to explode ×
(E) The hydrogen fuel cell demonstrated in class input hydrogen and oxygen gases ✓

5. The calculated cell potential for the Mg (s) + 2 Ag⁺ (aq) → Mg²⁺ (aq) + 2 Ag (s) cell is:

(A) + 1.556 V
(B) + 3.956 V
(C) - 1.556 V
(D) + 0.756 V
(E) + 3.156 V

\[ \text{Ag}^+ + \text{e}^- \rightarrow \text{Ag} \hspace{2cm} +0.800 \text{V} \]

\[ \text{Mg}^{2+} + 2\text{e}^- \rightarrow \text{Mg} \hspace{2cm} -2.356 \text{V} \]

6. A student provides a current of 8.00 amps through a solution of Co²⁺ (aq) for 6.00 hours. The voltage is such that cobalt metal is deposited at the cathode. The mass of cobalt deposited is:

(A) 12.2 g
(B) 24.4 g
(C) 62.1 g
(D) **52.8 g**
(E) 78.4 g

\[ 6.00 \text{ A} \left( \frac{3600 \text{ s}}{1 \text{ h}} \right) \left( \frac{8.00 \text{ C}}{1 \text{ mol e}^-} \right) \left( \frac{1 \text{ mol Co}}{2 \text{ mol e}^-} \right) \left( \frac{58.93 \text{ g}}{1 \text{ mol Co}} \right) = 52.8 \text{ g Co} \]
7. Consider \( \text{Cr}_2\text{O}_7^{2-} \) (aq), \( \text{Pb}^{2+} \) (aq), \( \text{S} \) (s), \( \text{NO}_3^- \) (aq), and \( \text{I}_2 \) (s). The strongest oxidizing agent is:

- (A) \( \text{Cr}_2\text{O}_7^{2-} \) (aq)
- (B) \( \text{Pb}^{2+} \) (aq)
- (C) \( \text{S} \) (s)
- (D) \( \text{NO}_3^- \) (aq)
- (E) \( \text{I}_2 \) (s)

8. When the reaction \( \text{Sn}^{2+} \) (aq) + \( \text{Mo}_2\text{O}_8^{4-} \) (aq) → \( \text{Mo}^{2+} \) (aq) + \( \text{Sn}^{4+} \) (aq) is correctly balanced in acid,

- (A) 3 protons (H\(^+\)) are consumed
- (B) 4 protons (H\(^+\)) are consumed
- (C) 8 protons (H\(^+\)) are consumed
- (D) 16 protons (H\(^+\)) are consumed
- (E) 42 protons (H\(^+\)) are consumed

\[
4 \times \left[ \text{Sn}^{2+} \rightarrow \text{Sn}^{4+} + 2e^- \right]
\]

\[
\left[ 8e^- + \frac{16}{12+} \text{H}^+ + \frac{\text{Mo}_2\text{O}_8^{4-}}{4+} \rightarrow 2 \text{Mo}^{2+} + 8 \text{H}_2\text{O} \right]
\]

\[
8e^- + 16\text{H}^+ + \text{Mo}_2\text{O}_8^{4-} + 4 \text{Sn}^{2+} \rightarrow 4 \text{Sn}^{4+} + 8e^- + 2 \text{Mo}^{2+} + 8\text{H}_2\text{O}
\]
9. $^{238}_{92}\text{U}^{2+}$ has:
(A) 238 protons and 92 neutrons and 236 electrons
(B) 92 protons and 238 neutrons and 90 electrons
(C) 92 protons and 146 neutrons and 90 electrons
(D) 146 protons and 92 neutrons and 144 electrons
(E) 238 protons and 238 neutrons and 236 electrons

\[ 238 - 92 = 146 \text{ n} \]
\[ 92 - 2 = 90 \text{ e}^- \]

10. Al-28 decays to produce a beta particle and ________________.
(A) $^{28}_{13}\text{Si}^{8}$
(B) Na-26
(C) Na-24
(D) U-238
(E) P-32

\[ ^{28}_{13}\text{Al} \rightarrow ^{0}_{-1}\text{e} + ^{28}_{14}\text{Si} \]

11. Pm-150 decays to produce an alpha particle and ________________.
(A) Pm-146
(B) $^{150}_{61}\text{Pr}$
(C) Pm-151
(D) Pr-150
(E) Sm-150

\[ ^{150}_{61}\text{Pm} \rightarrow ^{4}_{2}\text{X} + ^{96}_{59}\text{Pr} \]

12. Consider the generation of an x-ray. Which of the following is false?
(A) *An electron escapes the nucleus* ✗ Actualy, an $e^-$ is captured by the nucleus
(B) A high energy electron falls into a hole ✓
(C) An x-ray is generated from an electron transition ✓
(D) A proton is converted to a neutron ✓
(E) The x-ray released is electromagnetic radiation ✓
13. A student obtains a sample of C-11 (\( t_{1/2} = 20.39 \) minutes) containing 1.000 g. How long will it take for the sample to decay to 0.723 g of C-11?

(A) 8.54 minutes  
(B) 9.04 minutes  
(C) 9.54 minutes  
(D) 10.04 minutes  
(E) 10.54 minutes

- Calc \( k \) \[
\ln \frac{1}{2} = -k(20.39 \text{ min})
\]
- \( k = 0.0340 \text{ min}^{-1} \)
- Calc \( t \) \[
\ln \left[ \frac{0.723}{1.000} \right] = - (0.0340 \text{ min}^{-1}) t
\]
- \( t = 9.54 \text{ min} \)

14. Considering the carbon cycle and radiocarbon dating, which of the following statements is **false**?

(A) The carbon-14 concentration in fossils is less than the carbon-14 concentration in you. ✔
(B) Carbon-14 in living organisms does not undergo decay. ✗
(C) Carbon-14 can be used to date specimens previously in the carbon cycle. ✔
(D) Carbon-14 is generated in the upper atmosphere. ✔

15. Considering nuclear chemistry, which of the following statements is **false**?

(A) An example of nuclear fusion is \( ^1\text{H} + ^2\text{H} \rightarrow ^3\text{He} \) ✔
(B) An example of nuclear fission is \( ^{199}\text{Au} + ^{235}\text{U} \rightarrow ^{137}\text{Te} + ^{97}\text{Zr} + 2^{1}\text{H} \) ✔
(C) The half-life is the time required for a sample to decay to one-half its original amount ✔
(D) Gamma radiation has a mass of -1 ✗
(E) A Geiger Counter can be used to show that the orange pigment in certain ceramic glazes is radioactive ✔
16. Consider the band of stability (AKA "Belt of Stability"). What decay is expected for a species located to the top-right of stable isotopes in the belt?

(A) Alpha decay
(B) Beta decay
(C) Gamma decay
(D) Tooth decay
(D) Brain decay due to the overuse of Twitter

17. A radioactive decay series that begins with $^{232}$Th ends with formation of the stable nuclide $^{208}$Pb. How many alpha particle emissions and how many beta particle emissions are involved in the sequence of radioactive decays?

(A) 7 alpha and 6 beta decays
(B) 7 alpha and 4 beta decays
(C) 7 alpha and 2 beta decays
(D) 6 alpha and 2 beta decays
(E) 6 alpha and 4 beta decays

18. The complex:

(A) is the cis- isomer and it is polar
(B) is the trans- isomer and it is polar
(C) is the mer- isomer and it is polar
(D) is the fac- isomer and it is polar
(E) is the trans- isomer and it is non-polar
19. Consider $[\text{CoF}_2\text{Br}_4]^{3-}$. Which of the following is **false**?

(A) $\text{F}^-$ is a Lewis base ■ donates a pair of $\text{e}^-$ to form a new bond
(B) The cobalt ion ($\text{Co}^{3+}$) is the Lewis acid ■ accepts a pair of $\text{e}^-$ to form a new bond
(C) cis-$[\text{CoF}_2\text{Br}_4]^{3-}$ is polar □
(D) trans-$[\text{CoF}_2\text{Br}_4]^{3-}$ is nonpolar □
(E) $[\text{CoF}_2\text{Br}_4]^{3-}$ is a square planar complex □

$[\text{CoF}_2\text{Br}_4]^{3-}$ is octahedral

20. An example of a bidentate is:

(A) edta
(B) $\text{F}^-$ □
(C) $\text{Cu}^{2+}$ ■
(D) $\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2$ □
(E) $\text{H}_2\text{O}$ □

21. How many d-electrons does $\text{Cu}^{2+}$ have? $11-2=9$ □

(A) 7
(B) 8
(C) 9 □
(D) 10
(E) 11
22. The colors in transition metal complexes are due to:

(A) Electrons falling from high energy levels to low energy levels in split d-orbitals
(B) X-rays
(C) Gamma rays
(D) Electrons flowing through a filament
(E) Protons being converted to neutrons

23. Which of the following correctly depicts the curve of nuclear binding energy?

[A] Binding energy per nucleon

[B] Binding energy per nucleon

[C] Binding energy per nucleon

[D] Binding energy per nucleon

[Turn over for last page of the exam]
24. How many **unpaired** electrons are present in $[\text{Fe(NO}_2\text{]}_6]^{2-}$? 
[Fe is the Fe$^{3+}$ ion; (NO$_2$) is the NO$_2^-$ ion; and the Fe$^{3+}$ is **high spin**.]

(A) 1  
(B) 2  
(C) 3  
(D) 4  
(E) 5

$$\text{Fe}^{3+} \quad 8 - 3 = 5 \quad d^5$$

$\uparrow \quad \uparrow \quad \uparrow \quad \uparrow \quad \text{high spin}$

25. The CH 123 Final Exam is scheduled for Monday, June 8, 2009, 4:00-5:50pm. Which one of the following statements is **FALSE**?

(A) The CH 123 Final Exam is scheduled for Monday, June 8, 2009, 4:00-5:50pm
(B) The CH 123 Final Exam is scheduled for Monday, June 8, 2009, 4:00-5:50pm
(C) The CH 123 Final Exam is scheduled for Monday, June 8, 2009, 4:00-5:50pm
(D) **The oxidation number of Mn in MnO$_2$ is -4**
(E) The oxidation number of Mn in MnO$_2$ is +4

[Any response will receive full credit; even no response.]