**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⁻ > NO₃⁻ > en > NH₃ > NCS⁻ > H₂O > F⁻ > Cl⁻

F = 96,485 C/mole e⁻

Nₐ = 6.02 x 10²³
<table>
<thead>
<tr>
<th>Reductant Half-Reaction</th>
<th>$E^\circ$, volt</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acidic Solution</strong></td>
<td></td>
</tr>
<tr>
<td>$F_2(g) + 2 e^- \rightarrow 2F^-(aq)$</td>
<td>+2.866</td>
</tr>
<tr>
<td>$O_3(g) + 2 H^+(aq) + 2 e^- \rightarrow O_2(g) + H_2O(l)$</td>
<td>+2.075</td>
</tr>
<tr>
<td>$S_2O_7^{2-}(aq) + 2 e^- \rightarrow 2SO_4^{2-}(aq)$</td>
<td>+2.01</td>
</tr>
<tr>
<td>$H_2O_2(aq) + 2H^+(aq) + 2 e^- \rightarrow 2H_2O(l)$</td>
<td>+1.763</td>
</tr>
<tr>
<td>$MnO_4^-(aq) + 8H^+(aq) + 5 e^- \rightarrow Mn^{2+}(aq) + 4 H_2O(l)$</td>
<td>+1.51</td>
</tr>
<tr>
<td>$PbO_2(s) + 4H^+(aq) + 2 e^- \rightarrow Pb^{2+}(aq) + 2 H_2O(l)$</td>
<td>+1.455</td>
</tr>
<tr>
<td>$Cl_2(g) + 2 e^- \rightarrow 2Cl^-(aq)$</td>
<td>+1.358</td>
</tr>
<tr>
<td>$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6 e^- \rightarrow 2 Cr^{3+}(aq) + 7 H_2O(l)$</td>
<td>+1.33</td>
</tr>
<tr>
<td>$MnO_2(s) + 4H^+(aq) + 2 e^- \rightarrow Mn^{2+}(aq) + 2 H_2O(l)$</td>
<td>+1.23</td>
</tr>
<tr>
<td>$O_2(g) + 4H^+(aq) + 4 e^- \rightarrow 2 H_2O(l)$</td>
<td>+1.229</td>
</tr>
<tr>
<td>$2IO_2(aq) + 12H^+(aq) + 10 e^- \rightarrow I_2(s) + 6 H_2O(l)$</td>
<td>+1.20</td>
</tr>
<tr>
<td>$Br_2(l) + 2 e^- \rightarrow 2 Br^-(aq)$</td>
<td>+1.065</td>
</tr>
<tr>
<td>$NO_3^-(aq) + 4H^+(aq) + 3 e^- \rightarrow NO(g) + 2 H_2O(l)$</td>
<td>+0.956</td>
</tr>
<tr>
<td>$Ag^+(aq) + e^- \rightarrow Ag(s)$</td>
<td>+0.800</td>
</tr>
<tr>
<td>$Fe^3+(aq) + e^- \rightarrow Fe^{2+}(aq)$</td>
<td>+0.771</td>
</tr>
<tr>
<td>$O_2(g) + 2H^+(aq) + 2 e^- \rightarrow H_2O_2(aq)$</td>
<td>+0.695</td>
</tr>
<tr>
<td>$I_2(s) + 2 e^- \rightarrow 2 I^-(aq)$</td>
<td>+0.535</td>
</tr>
<tr>
<td>$Cu^{2+}(aq) + 2 e^- \rightarrow Cu(s)$</td>
<td>+0.340</td>
</tr>
<tr>
<td>$SO_4^{2-}(aq) + 4H^+(aq) + 2 e^- \rightarrow 2 H_2O(l) + SO_2(g)$</td>
<td>+0.17</td>
</tr>
<tr>
<td>$Sn^{4+}(aq) + 2 e^- \rightarrow Sn^{2+}(aq)$</td>
<td>+0.154</td>
</tr>
<tr>
<td>$S(s) + 2H^+(aq) + 2 e^- \rightarrow H_2S(g)$</td>
<td>+0.14</td>
</tr>
<tr>
<td>$2H^+(aq) + 2 e^- \rightarrow H_2(g)$</td>
<td>0</td>
</tr>
<tr>
<td>$Pb^{2+}(aq) + 2 e^- \rightarrow Pb(s)$</td>
<td>-0.125</td>
</tr>
<tr>
<td>$Sn^{2+}(aq) + 2 e^- \rightarrow Sn(s)$</td>
<td>-0.137</td>
</tr>
<tr>
<td>$Co^{2+}(aq) + 2 e^- \rightarrow Co(s)$</td>
<td>-0.277</td>
</tr>
<tr>
<td>$Fe^{2+}(aq) + 2 e^- \rightarrow Fe(s)$</td>
<td>-0.440</td>
</tr>
<tr>
<td>$Zn^{2+}(aq) + 2 e^- \rightarrow Zn(s)$</td>
<td>-0.763</td>
</tr>
<tr>
<td>$Al^{3+}(aq) + 3 e^- \rightarrow Al(s)$</td>
<td>-1.676</td>
</tr>
<tr>
<td>$Mg^{2+}(aq) + 2 e^- \rightarrow Mg(s)$</td>
<td>-2.556</td>
</tr>
<tr>
<td>$Na^+(aq) + e^- \rightarrow Na(s)$</td>
<td>-2.713</td>
</tr>
<tr>
<td>$Ca^{2+}(aq) + 2 e^- \rightarrow Ca(s)$</td>
<td>-2.84</td>
</tr>
<tr>
<td>$K^+(aq) + e^- \rightarrow K(s)$</td>
<td>-2.924</td>
</tr>
<tr>
<td>$Li^+(aq) + e^- \rightarrow Li(s)$</td>
<td>-3.040</td>
</tr>
<tr>
<td><strong>Basic Solution</strong></td>
<td></td>
</tr>
<tr>
<td>$O_3(g) + H_2O(l) + 2 e^- \rightarrow O_2(g) + 2 OH^-(aq)$</td>
<td>+1.246</td>
</tr>
<tr>
<td>$OCF_3(g) + H_2O(l) + 2 e^- \rightarrow CF_3^-(aq) + 2 OH^-(aq)$</td>
<td>+0.890</td>
</tr>
<tr>
<td>$O_2(g) + 2H_2O(l) + 4 e^- \rightarrow 4 OH^-(aq)$</td>
<td>+0.401</td>
</tr>
<tr>
<td>$2H_2O(l) + 2 e^- \rightarrow H_2(g) + 2 OH^-(aq)$</td>
<td>-0.828</td>
</tr>
</tbody>
</table>
1. The oxidation number of each vanadium in Li$_2$V$_2$O$_4$ is:

(A) $+2$
(B) $+3$
(C) $+4$
(D) $+5$
(E) $+6$

2. Consider the reaction $3 \text{Ag}^+ (aq) + \text{Al} (s) \rightarrow \text{AlF}_3 (aq) + 3 \text{Ag}^+ (s)$. The species being oxidized is:

(A) $\text{Ag}^+$ (aq)
(B) $\text{Al}$ (s)
(C) $\text{AlF}_3$ (aq)
(D) $\text{Ag}^+$ (s)

3. Consider a "Gestural Chemistry Battery" in which one beaker contains aqueous copper sulfate (CuSO$_4$) and a copper metal electrode and the other beaker contains aqueous zinc sulfate (ZnSO$_4$) and a zinc metal electrode. Which of the following statements is false?

(A) Cu$^{2+}$ (aq) is reduced
(B) The concentration of Zn$^{2+}$ (aq) increases as the process proceeds.
(C) The mass of copper electrode will increase as the process proceeds.
(D) Electrons flow from the copper beaker to the zinc beaker.
(E) A salt bridge is needed to allow the flow of ions.

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. FALSE.
(E) The hydrogen fuel cell demonstrated in class input hydrogen and oxygen gases.
5. The calculated cell potential (voltage) for: \( 2 \text{Li}^+ (\text{aq}) + \text{Cu}^{2+} (\text{aq}) \rightarrow 2 \text{Li}^+ (\text{aq}) + \text{Cu} (s) \) is:

\[ \varepsilon^0 (\text{volts}) \]

(A) + 0.340 V.  
(B) + 2.700 V.  
(C) + 3.040 V.  
(D) + 3.380 V.  
(E) + 9.906 V.  

\[ \text{Cu}^{2+} + 2e^- \rightarrow \text{Cu} \quad + 0.340 \text{V} \]

\[ \text{Li}^+ + e^- \rightarrow \text{Li} \quad - 3.040 \text{V} \]

The difference is + 3.380 V.

\[ \text{Do not multiply } -3.040 \times 2 \]

6. A student provides a current of 8.0 amps through a solution of \( \text{Co}^{2+} (\text{aq}) \) 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.

\[ \text{Co}^{2+} + 2e^- \rightarrow \text{Co} \]

\[ 6.00 \text{amp} \times \frac{3600 \text{sec}}{1 \text{hr}} \times \frac{8.00 \text{C}}{1 \text{amp}} \times \frac{1 \text{mol Co}}{96,485 \text{C}} \times \frac{56.93829 \text{g}}{1 \text{mol Co}} = 52.8 \text{g Co} \]

7. Consider \( \text{Na}^+ (\text{aq}), \text{Pb}^{2+} (\text{aq}), \text{Zn}^{2+} (\text{aq}), \text{Ag}^+ (\text{aq}), \) and \( \text{Li}^+ (\text{aq}) \). The strongest oxidizing agent is:

(A) \( \text{Na}^+ (\text{aq}) \).  
(B) \( \text{Pb}^{2+} (\text{aq}) \).  
(C) \( \text{Zn}^{2+} (\text{aq}) \).  
(D) \( \text{Ag}^+ (\text{aq}) \).  
(E) \( \text{Li}^+ (\text{aq}) \).
8. When the reaction $\text{Al} (s) + \text{Cr}_2\text{O}_7^{2-} (aq) \rightarrow \text{Cr}^{3+} (aq) + \text{Al}^{3+} (aq)$ is correctly balanced in acid,

(A) 3 protons ($\text{H}^+$) are consumed.
(B) 7 protons ($\text{H}^+$) are consumed.
(C) 8 protons ($\text{H}^+$) are consumed.
(D) 12 protons ($\text{H}^+$) are consumed.
(E) 42 protons ($\text{H}^+$) are consumed.

\[
\begin{align*}
8 \times & \left[ \text{Al} \rightarrow \text{Al}^{3+} + 3 \text{e}^- \right] \\
3 \times & \left[ 8 \text{e}^- + 14 \text{H}^+ + \text{Cr}_2\text{O}_7^{2-} \rightarrow 2 \text{Cr}^{3+} + 7 \text{H}_2\text{O} \right]
\end{align*}
\]

\[
\text{BA} + 2\text{H}^+ + 2\text{e}^- + 3 \text{Cr}_2\text{O}_7^{2-} \rightarrow \text{BA}^{3+} + 2\text{H}_2\text{O} + 6 \text{Cr}^{3+} + 2\text{H}_2\text{O}
\]

9. When a beta particle is emitted,

(A) An electron is converted to a helium nucleus.
(B) A gamma ray is released.
(C) Two gamma rays are released.
(D) A proton is converted to a neutron.
(E) A neutron is converted to a proton.

\[
\begin{align*}
\text{n} \rightarrow & \text{p} \\
\alpha & = \text{He}^+ \text{ nucleus} \\
\beta & = \text{neutron}
\end{align*}
\]
10. Al-28 decays to produce a beta particle and _____________.
   (A) Si-28
   (B) Na-26
   (C) Na-24
   (D) U-238
   (E) P-32.

\[
\begin{align*}
\text{\( ^{27}\text{Al} \rightarrow ^{0}\beta + ^{28}\text{Si} \)}
\end{align*}
\]

11. Pm-150 decays to produce an alpha particle and _____________.
   (A) Pm-146
   (B) Pr-146
   (C) Pm-151
   (D) Pr-150
   (E) Sn-150.

\[
\begin{align*}
\text{\( ^{150}\text{Pm} \rightarrow ^{4}\alpha + ^{146}\text{Pr} \)}
\end{align*}
\]

12. \(^{60}\)Co decays to produce gamma electromagnetic radiation and _____________.
   (A) Ni-60
   (B) Ni-59
   (C) Mn-56
   (D) Co-60
   (E) Mn-60.

\[
\begin{align*}
\text{\( ^{60}\text{Co} \rightarrow y + ^{60}\text{Co} \)}
\end{align*}
\]

13. Consider \(^{247}\)Bk. \(^{247}\)Bk has:
   (A) 97 protons and 247 neutrons.
   (B) 150 protons and 97 neutrons.
   (C) 97 protons and 150 neutrons.
   (D) 247 protons and 247 neutrons.
   (E) 247 protons and 238 neutrons.

\[
\begin{align*}
\text{\( ^{247}\text{Bk} \rightarrow ^{147}\text{P} + ^{97}\text{Bk} \)}
\end{align*}
\]

\[
\begin{align*}
\text{\( \text{n} = 247 - 97 = 150 \)}
\end{align*}
\]
14. A student obtains a sample containing 0.02000 grams Cu-64 (t1/2 = 12.8 hours). How long will it take for the sample to contain only 0.01242 grams of Cu-64?

(A) 20.6 hours
(B) 6.621 hours
(C) 1.61 hours
(D) 11.2 hours
(E) 8.79 hours

\[ \ln \left( \frac{1}{2} \right) = -k \cdot \frac{t}{t_{1/2}} \]
\[ -0.6931 = -k(12.8 \text{ h}) \]
\[ k = 0.0542 \text{ h}^{-1} \]

\[ \ln \left( \frac{A}{A_0} \right) = -kt \]
\[ \ln \left( \frac{0.01242}{0.02000} \right) = -(0.0542 \text{ h}^{-1})t \]
\[ t = 8.79 \text{ h} \]

15. Consider the band of stability (AKA “Belt of Stability” located near the beginning of the exam). What decay is expected for a species located to the left of the belt?

(A) Alpha decay
(B) Beta decay
(C) Gamma decay
(D) Tooth decay
(E) Urban decay

![Diagram of decay](Image)

A radioactive decay series that begins with $^{252}$Es ends with formation of the stable nuclide $^{209}$Bi. How many alpha particle emissions and how many beta particle emissions are involved in the sequence of radioactive decays?

(A) 11 alpha and 4 beta decays.
(B) 11 alpha and 6 beta decays.
(C) 7 alpha and 4 beta decays.
(D) 4 alpha and 11 beta decays.
(E) 6 alpha and 11 beta decays.

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

(A) An example of nuclear fission is $^1\text{H} + ^7\text{H} \rightarrow ^3\text{He}$.
(B) An example of nuclear fission is $^{235}\text{U} + ^{1}\text{n} \rightarrow ^{137}\text{Te} + ^{92}\text{Zr} + 2^{1}\text{n}$.
(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 $0.125$.
(E) A Geiger Counter can be used to show that the orange pigment in certain ceramic glazes is radioactive.
18. Consider $[\text{CoF}_{3}\text{Br}]^{2+}$. Which of the following is false?
   (A) $F^-$ is a Lewis base. **True**
   (B) The cobalt ion (Co$^{2+}$) is the Lewis acid. **True**
   (C) cis-$[\text{CoF}_{3}\text{Br}]^{2+}$ is polar. **True**
   (D) trans-$[\text{CoF}_{3}\text{Br}]^{2+}$ is nonpolar. **True**
   (E) $[\text{CoF}_{3}\text{Br}]^{2+}$ is a square planar complex. **FALSE**

19. Consider coordination chemistry. Which of the following is a Lewis acid?
   (A) $\text{NH}_3$
   (B) $\text{F}^-$
   (C) $\text{Co}^{2+}$
   (D) $\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2$
   (E) $\text{H}_2\text{O}$

20. An example of a bidentate is:
   (A) $\text{dta}$, hexadentate
   (B) $\text{F}^-$, monodentate
   (C) $\text{Cu}^{2+}$, monodentate
   (D) $\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2$
   (E) $\text{H}_2\text{O}$, monodentate

21. The coordination number for Fe in $[\text{Fe(ox)}_3]^{3+}$ is:
   (A) 1
   (B) 2
   (C) 3
   (D) 4
   (E) 6

22. The complex:

   (A) is cis-$[\text{CuCl}_2\text{F}]^+$
   (B) is trans-$[\text{CuCl}_2\text{F}]^+$
   (C) is fac-$[\text{CuCl}_2\text{F}]^+$
   (D) is mer-$[\text{CuCl}_2\text{F}]^+$
   (E) is mp-$[\text{CuCl}_2\text{F}]^+$

[Turn over for the last page of the exam]
23. How many $d$-electrons does Cu$^{2+}$ have?
   (A) 7. 
   (B) 8. 
   (C) 9. 
   (D) 10. 
   (E) 11. 

   $\text{Cu}^{2+}$: $11 - 2 = 9 \text{ e}^-$

24. How many unpaired electrons are present in [Mn(CN)$_6$]$^{4+}$?
   [Mn is the Mn$^{2+}$ ion; CN is the CN$^-$ ion; and the Mn$^{2+}$ is low spin].
   (A) 0.
   (B) 1.
   (C) 2.
   (D) 3.
   (E) 5.

   $\text{Mn}^{2+}$: $7 - 2 = 5 \text{ e}^-$

25. The CH 123 Final Exam is scheduled for Wednesday, June 8, 2004, 7:30-9:20am. Rooms will be assigned and posted near the conclusion of the term.

Which one of the following statements is FALSE?
   (A) The CH 123 Final Exam is scheduled for Wednesday, June 8 at 7:30am.
   (B) The CH 123 Final Exam is scheduled for Wednesday, June 8 at 7:30am.
   (C) The CH 123 Final Exam is scheduled for Wednesday, June 8 at 7:30am.
   (D) The CH 123 Final Exam is scheduled for Wednesday, June 8 at 7:30am.
   (E) The oxidation number of Mo in MoO$_2$ is -4.