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

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 last name, first name, middle initial, and student identification number. Leave the test form number and class section number blank.

This exam consists of 36 multiple-choice questions. Each question has four points associated with it; except Question 36 which has five 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.
<table>
<thead>
<tr>
<th>Reduction Half-Reaction</th>
<th>$E^\circ$, volt</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acidic Solution</strong></td>
<td></td>
</tr>
<tr>
<td>$\text{F}_2(g) + 2 \text{e}^- \rightarrow 2\text{F}^-(aq)$</td>
<td>$+2.866$</td>
</tr>
<tr>
<td>$\text{O}_3(g) + 2 \text{H}^+(aq) + 2 \text{e}^- \rightarrow \text{O}_2(g) + \text{H}_2\text{O(l)}$</td>
<td>$+2.075$</td>
</tr>
<tr>
<td>$\text{S}_2\text{O}_8^{2-}(aq) + 2 \text{e}^- \rightarrow 2\text{SO}_4^{2-}(aq)$</td>
<td>$+2.01$</td>
</tr>
<tr>
<td>$\text{H}_2\text{O}_2(aq) + 2\text{H}^+(aq) + 2 \text{e}^- \rightarrow 2\text{H}_2\text{O(l)}$</td>
<td>$+1.763$</td>
</tr>
<tr>
<td>$\text{Mn}_3\text{O}_4(aq) + 8\text{H}^+(aq) + 5 \text{e}^- \rightarrow \text{Mn}^{2+}(aq) + 4\text{H}_2\text{O(l)}$</td>
<td>$+1.51$</td>
</tr>
<tr>
<td>$\text{PbO}_2(s) + 4\text{H}^+(aq) + 2 \text{e}^- \rightarrow \text{Pb}^{2+}(aq) + 2\text{H}_2\text{O(l)}$</td>
<td>$+1.455$</td>
</tr>
<tr>
<td>$\text{Cl}_2(g) + 2 \text{e}^- \rightarrow 2\text{Cl}^-(aq)$</td>
<td>$+1.358$</td>
</tr>
<tr>
<td>$\text{Cr}_2\text{O}_7^{2-}(aq) + 14 \text{H}^+(aq) + 6 \text{e}^- \rightarrow 2\text{Cr}^{3+}(aq) + 7\text{H}_2\text{O(l)}$</td>
<td>$+1.33$</td>
</tr>
<tr>
<td>$\text{Mn}_2\text{O}_3(s) + 4\text{H}^+(aq) + 2 \text{e}^- \rightarrow \text{Mn}^{2+}(aq) + 2\text{H}_2\text{O(l)}$</td>
<td>$+1.23$</td>
</tr>
<tr>
<td>$\text{O}_2(g) + 4\text{H}^+(aq) + 4 \text{e}^- \rightarrow 2\text{H}_2\text{O(l)}$</td>
<td>$+1.229$</td>
</tr>
<tr>
<td>$2\text{IO}_3^-(aq) + 12\text{H}^+(aq) + 10 \text{e}^- \rightarrow \text{I}_2(s) + 6\text{H}_2\text{O(l)}$</td>
<td>$+1.20$</td>
</tr>
<tr>
<td>$\text{Br}_2(l) + 2 \text{e}^- \rightarrow 2\text{Br}^-(aq)$</td>
<td>$+1.065$</td>
</tr>
<tr>
<td>$\text{NO}_3^-(aq) + 4\text{H}^+(aq) + 3 \text{e}^- \rightarrow \text{NO(g)} + 2\text{H}_2\text{O(l)}$</td>
<td>$+0.956$</td>
</tr>
<tr>
<td>$\text{Ag}^+(aq) + \text{e}^- \rightarrow \text{Ag}(s)$</td>
<td>$+0.800$</td>
</tr>
<tr>
<td>$\text{Fe}^{3+}(aq) + \text{e}^- \rightarrow \text{Fe}^{2+}(aq)$</td>
<td>$+0.771$</td>
</tr>
<tr>
<td>$\text{O}_2(g) + 2\text{H}^+(aq) + 2 \text{e}^- \rightarrow \text{H}_2\text{O}_2(aq)$</td>
<td>$+0.695$</td>
</tr>
<tr>
<td>$\text{I}_2(s) + 2 \text{e}^- \rightarrow 2\text{I}^-(aq)$</td>
<td>$+0.535$</td>
</tr>
<tr>
<td>$\text{Cu}^{2+}(aq) + 2 \text{e}^- \rightarrow \text{Cu}(s)$</td>
<td>$+0.340$</td>
</tr>
<tr>
<td>$\text{SO}_4^{2-}(aq) + 4\text{H}^+(aq) + 2 \text{e}^- \rightarrow 2\text{H}_2\text{O(l)} + \text{SO}_2(g)$</td>
<td>$+0.17$</td>
</tr>
<tr>
<td>$\text{Sn}^{4+}(aq) + 2 \text{e}^- \rightarrow \text{Sn}^{2+}(aq)$</td>
<td>$+0.154$</td>
</tr>
<tr>
<td>$\text{S}(s) + 2\text{H}^+(aq) + 2 \text{e}^- \rightarrow \text{H}_2\text{S(g)}$</td>
<td>$+0.14$</td>
</tr>
<tr>
<td>$2\text{H}^+(aq) + 2 \text{e}^- \rightarrow \text{H}_2(g)$</td>
<td>$0$</td>
</tr>
<tr>
<td>$\text{Pb}^{2+}(aq) + 2 \text{e}^- \rightarrow \text{Pb}(s)$</td>
<td>$-0.125$</td>
</tr>
<tr>
<td>$\text{Sn}^{2+}(aq) + 2 \text{e}^- \rightarrow \text{Sn}(s)$</td>
<td>$-0.137$</td>
</tr>
<tr>
<td>$\text{Co}^{2+}(aq) + 2 \text{e}^- \rightarrow \text{Co}(s)$</td>
<td>$-0.277$</td>
</tr>
<tr>
<td>$\text{Fe}^{2+}(aq) + 2 \text{e}^- \rightarrow \text{Fe}(s)$</td>
<td>$-0.440$</td>
</tr>
<tr>
<td>$\text{Zn}^{2+}(aq) + 2 \text{e}^- \rightarrow \text{Zn}(s)$</td>
<td>$-0.763$</td>
</tr>
<tr>
<td>$\text{Al}^{3+}(aq) + 3 \text{e}^- \rightarrow \text{Al}(s)$</td>
<td>$-1.676$</td>
</tr>
<tr>
<td>$\text{Mg}^{2+}(aq) + 2 \text{e}^- \rightarrow \text{Mg}(s)$</td>
<td>$-2.356$</td>
</tr>
<tr>
<td>$\text{Na}^+(aq) + \text{e}^- \rightarrow \text{Na}(s)$</td>
<td>$-2.713$</td>
</tr>
<tr>
<td>$\text{Ca}^{2+}(aq) + 2 \text{e}^- \rightarrow \text{Ca}(s)$</td>
<td>$-2.84$</td>
</tr>
<tr>
<td>$\text{K}^+(aq) + \text{e}^- \rightarrow \text{K}(s)$</td>
<td>$-2.924$</td>
</tr>
<tr>
<td>$\text{Li}^+(aq) + \text{e}^- \rightarrow \text{Li}(s)$</td>
<td>$-3.040$</td>
</tr>
<tr>
<td><strong>Basic Solution</strong></td>
<td></td>
</tr>
<tr>
<td>$\text{O}_3(g) + \text{H}_2\text{O(l)} + 2 \text{e}^- \rightarrow \text{O}_2(g) + 2\text{OH}^-(aq)$</td>
<td>$+1.246$</td>
</tr>
<tr>
<td>$\text{OC}l^-(g) + \text{H}_2\text{O(l)} + 2 \text{e}^- \rightarrow \text{Cl}^-(aq) + 2\text{OH}^-(aq)$</td>
<td>$+0.890$</td>
</tr>
<tr>
<td>$\text{O}_2(g) + 2\text{H}_2\text{O(l)} + 4 \text{e}^- \rightarrow 4\text{OH}^-(aq)$</td>
<td>$+0.401$</td>
</tr>
<tr>
<td>$2\text{H}_2\text{O(l)} + 2 \text{e}^- \rightarrow \text{H}_2(g) + 2\text{OH}^-(aq)$</td>
<td>$-0.828$</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td><strong>Arginine</strong></td>
<td><strong>Glutamine</strong></td>
</tr>
<tr>
<td>(Arg / R)</td>
<td>(Gln / Q)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lysine</strong></td>
<td><strong>Glycine</strong></td>
</tr>
<tr>
<td>(Lys / K)</td>
<td>(Gly / G)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Proline</strong></td>
<td><strong>Glutamic Acid</strong></td>
</tr>
<tr>
<td>(Pro / P)</td>
<td>(Glu / E)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Methionine</strong></td>
<td><strong>Leucine</strong></td>
</tr>
<tr>
<td>(Met / M)</td>
<td>(Leu / L)</td>
</tr>
</tbody>
</table>
## Selected Functional Groups:

<table>
<thead>
<tr>
<th>Name</th>
<th>Condensed Formula</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>alkene</td>
<td>R₂C=CR₂</td>
<td>contains a C=C double bond</td>
</tr>
<tr>
<td>alkyne</td>
<td>RC=CR</td>
<td>contains a C=CR triple bond</td>
</tr>
<tr>
<td>alcohol</td>
<td>ROH</td>
<td>contains O singly bonded to a C and a H</td>
</tr>
<tr>
<td>thiol (thiol alcohol)</td>
<td>RSH</td>
<td>contains S singly bonded to a C and a H</td>
</tr>
<tr>
<td>Disulfide</td>
<td>SS</td>
<td>contains S singly bonded to an S</td>
</tr>
<tr>
<td>ether</td>
<td>ROR</td>
<td>contains O singly bonded to two C</td>
</tr>
<tr>
<td>aldehyde</td>
<td>RCHO</td>
<td>contains C doubly bonded to O and singly to H</td>
</tr>
<tr>
<td>ketone</td>
<td>RCOR</td>
<td>contains C doubly bonded to O and singly to two C</td>
</tr>
<tr>
<td>hemiacetal</td>
<td>ROCH₃</td>
<td>contains C singly bonded to O of ether and of alcohol</td>
</tr>
<tr>
<td>carboxylic acid</td>
<td>RCOOH</td>
<td>contains C doubly bonded to O and singly to O of OH</td>
</tr>
<tr>
<td>ester</td>
<td>RCOOR</td>
<td>contains C doubly bonded to O and singly to O</td>
</tr>
<tr>
<td>amine</td>
<td>N</td>
<td>contains N bonded to C and/or H</td>
</tr>
<tr>
<td>amide</td>
<td>RCONR</td>
<td>contains C doubly bonded to O and singly to N</td>
</tr>
</tbody>
</table>

**aromatic**

contains a flat six-member ring

## Possibly Useful Information:

\[
\begin{align*}
K_a[\text{HCOOH (aq)}] &= 1.80 \times 10^{-4} \\
K_a[\text{CH₂ClCOOH (aq)}] &= 1.40 \times 10^{-3} \\
K_a[\text{CH₃COOH (aq)}] &= 1.80 \times 10^{-5} \\
K_a[\text{C₆H₅O₄ (aq)}] &= 3.0 \times 10^{-4} \\
K_a[\text{NH₄⁺ (aq)}] &= 5.6 \times 10^{-10} \\
1 \text{ Amp} &= 1 \text{ Coulomb/second} \\
K_{sp}[\text{PbF₂, lead fluoride}] &= 3.6 \times 10^{-8} \\
K_{sp}[\text{MgF₂, mag fluoride}] &= 3.7 \times 10^{-8} \\
K_a[\text{C₆H₅COOH (aq)}] &= 6.30 \times 10^{-5} \\
K_b[\text{NH₃ (aq)}] &= 1.80 \times 10^{-5} \\
K_a[\text{C₆H₅O₆ (aq)}] &= 8.00 \times 10^{-5} \\
R &= 8.314 \text{ J/mol} \cdot \text{K} \\
F &= 96,485 \text{ Coulombs/mole e⁻} \\
N_A &= 6.02 \times 10^{23}
\end{align*}
\]
1. A student prepares a solution of 0.0800 M nitric acid, HNO₃ (aq). The pH is:

(A) 1.10
(B) 0.0800
(C) 0.900
(D) 0.00120
(E) 1.20

\[ HNO_3(aq) \rightarrow H^+ (aq) + NO_3^-(aq) \]

\[ [H^+] = \frac{0.0800 M}{0.0800 M} = 1.10 \]

2. A student prepares a solution of 0.670 M benzoic acid, C₆H₅COOH (aq). The [OH⁻] is:

(A) 0.250 M
(B) 1.250 M
(C) 0.899 M
(D) 1.54 x 10⁻¹² M
(E) 0.00650 M

\[ C_6H_5COOH(aq) \rightleftharpoons C_6H_5COO^-(aq) + H^+(aq) \]

\[ K_a = 6.30 \times 10^{-5} = \frac{x^2}{0.670-x} \]

\[ x = [H^+] = 0.00650 \text{ M} \]

\[ pH = -\log (0.00650) = 2.19 \]

\[ pOH = 14 - pH = 11.8 \]

\[ [OH^-] = 10^{-pOH} = 10^{-11.8} = 1.54 \times 10^{-12} \text{ M} \]

3. A student titrates 0.5222 grams of KHP (potassium hydrogen phthalate; MW=204.2 g/mol) to the equivalence point with 24.08 mL of NaOH (aq). The concentration of the NaOH solution is:

(A) 0.09722 M
(B) 0.1722 M
(C) 0.1062 M
(D) 1.722 x 10⁻⁴ M
(E) 9.416 M

\[ \frac{\text{moles}_{\text{KHP}}}{\text{MWT}_{\text{KHP}}} \cdot \text{V}_{\text{NaOH}} \]

\[ \frac{0.5222 g}{204.2 g/mol} = \text{M}_{\text{NaOH}} \cdot 0.02408 L \]

\[ \text{M}_{\text{NaOH}} = 0.1062 \text{ M} \]
4. The pH of a buffer system which is 0.885 M $C_6H_5COOH$ (aq) and 0.885 M $C_6H_5COONa$ (aq) is:

(A) 0.0531  
(B) 4.20  
(C) 4.32  
(D) 7.24  
(E) 13.12

\[
\begin{align*}
C_6H_5COOH (aq) & \rightleftharpoons C_6H_5COO^- (aq) + H^+ (aq) \\
\text{Ka} = 6.3 \times 10^{-5} & = \frac{[C_6H_5COO^-] [H^+]}{[C_6H_5COOH]} = \frac{(0.885 \text{ M}) [H^+]}{(0.885 \text{ M})}
\end{align*}
\]

\[
[H^+] = 6.3 \times 10^{-5}
\]

\[
\text{pH} = -\log [H^+] = -\log (6.3 \times 10^{-5}) = 4.20
\]

5. The pH of 0.200 M $NH_4NO_3$ (aq), is:

(A) Greater than 7.00  
(B) 7.00  
(C) Less than 7.00

\[
\begin{align*}
\text{NO}_3^- & \text{ spectator ion} \\
\text{NH}_4^+ \text{ acid & NH}_4^+ & \rightleftharpoons \text{NH}_3 + H^+ \\
\text{pH} & < 7
\end{align*}
\]

6. Consider the reaction of ammonia ($NH_3$), and water. The conjugate acid is:

(A) $H_2O$  
(B) $NH_3$  
(C) $HCOO^-$  
(D) $H^+$  
(E) $NH_4^+$

\[
\begin{align*}
\text{NH}_3 (aq) + H_2O (l) & \rightleftharpoons \text{NH}_4^+ (aq) + \text{OH}^- (aq) \\
\text{base & acid} & \text{conjugate acid & conjugate base}
\end{align*}
\]
7. Which of the following processes exhibits an increase in entropy of the system?

(A) NH₄NO₃ (aq) → NH₄NO₃ (s)  
(B) C₂H₅CH₂OH (l) → CH₃CH₂OH (s)  
(C) N₂O₄ (g) → 2 NO₂ (g)  
(D) H₂O (g) → H₂O (s)  
(E) CH₃OH (g) → CH₃OH (l)

The system goes to more disorder

8. The system CaO (s) + C (graphite) ↔ Ca (s) + CO (g) is allowed to reach equilibrium where q_rev is measured to be 303 kJ at 298 K. ΔS is:

(A) 0.984 J/K  
(B) -0.984 J/K  
(C) -101 J/K  
(D) 101 J/K  
(E) 9.84 x 10⁵ J/K

\[ \Delta S = \frac{q_{rev}}{T} = \frac{303,000 \text{ J}}{298 \text{ K}} = 1.02 \times 10^3 \text{ J/K} \]

9. The combustion of propane is:

\[ \text{C}_3\text{H}_8 (g) + 5 \text{ O}_2 (g) \rightarrow 3 \text{ CO}_2 (g) + 4 \text{ H}_2\text{O (l)} \]

\[ 270.2 \quad \text{kJ} \ 	imes \frac{5}{5} \times 205.0 \text{ J/K} \ 	imes \frac{3}{3} \times 213.6 \text{ J/K} \ 	imes \frac{4}{4} \times 69.91 \text{ J/K} \]

\[ \Delta S^{\circ}_{\text{reaction}} (298 \text{ K}) \text{ for the combustion of propane is:} \]

(A) -374.8 J/K  
(B) +393.5 J/K  
(C) 0 J/K  
(D) -393.5 J/K  
(E) +374.8 J/K

\[ \Delta S^{\circ}_{\text{reaction}} = (3 \times 213.6 \frac{\text{J}}{\text{mol.K}}) + (4 \times 69.91 \frac{\text{J}}{\text{mol.K}}) \frac{1}{(1 \times 270.2 \frac{\text{J}}{\text{mol.K}}) + (5 \times 205.0 \frac{\text{J}}{\text{mol.K}})} \]

\[ > -374.8 \frac{\text{J}}{\text{K}} \]
10. Determine ΔS for the reaction \(2 \text{C}_2\text{H}_4\text{O} (l) + 2 \text{H}_2\text{O} (l) \rightarrow 2 \text{C}_2\text{H}_6\text{O} (l) + \text{O}_2 (g)\) using the following two reactions:

\[(1) \quad 2 \text{CO}_2 (g) + 3 \text{H}_2\text{O} (l) \rightarrow \text{C}_2\text{H}_6\text{O} (l) + 3 \text{O}_2 (g) \quad \Delta S_1 = +371 \text{ kJ}\]

\[(2) \quad 2 \text{CO}_2 (g) + 2 \text{H}_2\text{O} (g) \rightarrow \text{C}_2\text{H}_4\text{O} (l) + 5/2\text{O}_2 (g) \quad \Delta S_2 = -1167 \text{ kJ}\]

\[(1') \quad 4 \text{CO}_2 + 6 \text{H}_2\text{O} \rightarrow 2 \text{C}_2\text{H}_6\text{O} + 6 \text{O}_2 \quad \Delta S' = +742 \text{ kJ}\]

\[(2') \quad 2 \text{C}_2\text{H}_4\text{O} + 5 \text{O}_2 \rightarrow 4 \text{CO}_2 + 4 \text{H}_2\text{O} \quad \Delta S'' = +2334 \text{ kJ}\]

\[
2 \text{C}_2\text{H}_4\text{O} + 2 \text{H}_2\text{O} \rightarrow 2 \text{C}_2\text{H}_6\text{O} + \text{O}_2 \quad \Delta S = +3076 \text{ kJ}
\]

(A) - 796 kJ
(B) + 1538 kJ
(C) - 1592 kJ
(D) + 3076 kJ
(E) - 1963 kJ

11. The oxidation number of each tungsten in SrW\(_2\)O\(_5\) is:

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

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

(A) Na\(^+\) \((\text{aq})\)
(B) Pb\(^{2+}\) \((\text{aq})\)
(C) Zn\(^{2+}\) \((\text{aq})\)
(D) Ag\(^+\) \((\text{aq})\)
(E) Li\(^+\) \((\text{aq})\)
13. Consider a "General Chemistry Battery" in which one beaker contains aqueous tin sulfate (SnSO₄) and a tin metal electrode and the other beaker contains aqueous lead sulfate (PbSO₄) and a lead metal electrode. Which of the following statements is false?

(A) The mass of the tin electrode will decrease as the process proceeds ✓
(B) Sn²⁺ (aq) is oxidized False Pb²⁺ is reduced and Sn⁰ is oxidized
(C) Electrons flow from the tin beaker to the lead beaker ✓
(D) The cell potential is 0.012 V ✓
(E) The concentration of Pb²⁺ (aq) decreases as the process proceeds ✓

14. A student provides a current of 5.500 amps through an aqueous solution of AgNO₃ for 3.000 hours. The voltage is such that silver metal is deposited at the cathode. The mass of silver deposited is:

(A) 66.42 g
(B) 121.3 g
(C) 40.43 g
(D) 161.7 g
(E) 5.45 g

15. Consider F₂ (g), Cl₂ (g), Cu²⁺ (aq), H⁺ (aq), and Li⁺ (aq). The strongest oxidizing agent is:

(A) F₂ (g)
(B) Cl₂ (g)
(C) Cu²⁺ (aq)
(D) H⁺ (aq)
(E) Li⁺ (aq)
16. When the reaction $\text{Mn}^{2+} \text{(aq)} + \text{BiO}_3^- \text{(aq)} \rightarrow \text{Bi}^{3+} \text{(aq)} + \text{MnO}_4^- \text{(aq)}$ is correctly balanced in acid,

(A) 1 $\text{BiO}_3^-$ (aq) is consumed
(B) 2 $\text{BiO}_3^-$ (aq) are consumed
(C) 3 $\text{BiO}_3^-$ (aq) are consumed
(D) 6 $\text{BiO}_3^-$ (aq) are consumed
(E) 8 $\text{BiO}_3^-$ (aq) are consumed

\[
\left[ \frac{4 \text{H}_2\text{O} + \text{Mn}^{2+} \rightarrow \text{MnO}_4^- + 8 \text{H}^+ + 5 \text{e}^-}{2^+} \right] \times 2
\]

\[
\left[ 2 \text{e}^- + \frac{6 \text{H}^+ + \text{BiO}_3^- \rightarrow \text{Bi}^{3+} + 3 \text{H}_2\text{O}}{5^+} \right] \times 5
\]

$8 \text{H}_2\text{O} + 2 \text{Mn}^{2+} + 10\text{e}^- + 30\text{H}^+ + 5\text{BiO}_3^- \rightarrow 2 \text{MnO}_4^- + 16\text{H}^+ + 10\text{e}^- + 5 \text{Bi}^{3+} + 15 \text{H}_2\text{O}$

17. 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

1. Calc $K$

\[ \ln \frac{A}{A_0} = -kt \]

$-0.6931 = -k(20.39 \text{ min})$

$k = 0.0340 \text{ min}^{-1}$

2. Calc +

\[ \ln \frac{A}{A_0} = -kt \]

$\ln \frac{0.723}{1.000} = -(0.0340 \text{ min}^{-1})(t)$

$t = 9.59 \text{ min}$
18. When an X-ray is generated,

(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

19. A radioactive decay series that begins with $^{259}\text{No}$ ends with formation of the stable nuclide $^{211}\text{Bi}$. How many alpha particle emissions and how many beta particle emissions are involved in the sequence of radioactive decays?

(A) 7 alpha and 22 beta decays.
(B) 14 alpha and 11 beta decays.
(C) 48 alpha and 24 beta decays.
(D) 12 alpha and 11 beta decays.
(E) 12 alpha and 5 beta decays.

20. How many unpaired electrons are present in $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$? [Fe is the Fe$^{3+}$ ion; H$_2$O is water; and the Fe$^{3+}$ is high spin].

(A) 0
(B) 1
(C) 2
(D) 3
(E) 5
21. The complex:

\[
\text{Cl} \quad \text{Cl} \quad \text{Cl} \quad \text{F} \quad \text{F} \quad \text{F} \\
\text{Cl} \quad \text{Cl} \quad \text{Fe} \\
\text{F} \quad \text{F} \\
\text{mer-} \quad \text{mer-}
\]

(A) is cis-\([\text{FeCl}_3\text{F}_3]^{3-}\)
(B) is trans-\([\text{FeCl}_3\text{F}_3]^{3-}\)
(C) is mer-\([\text{FeCl}_3\text{F}_3]^{3-}\)
(D) is fac-\([\text{FeCl}_3\text{F}_3]^{3-}\)
(E) is Usher-\([\text{FeCl}_3\text{F}_3]^{3-}\)

22. In a condensation reaction, an ester is produced from:

(A) a ketone and a carboxylic acid
(B) an alcohol and a carboxylic acid
(C) a alkene and a carboxylic acid
(D) an aldehyde and a ketone
(E) an amide and an alkene

\[
\text{R-CH}+\text{HO}^{\circ}\text{C-R} \rightarrow \text{R-O-C-R}
\]

alcohol          carboxylic acid           ester
23. An organic compound with the formula C_{106}H_{198} is:

(A) an alkane
(B) an amino acid
(C) an alkyn
(D) an ester
(E) an amide

24. The systematic name of

\[4\text{-ethyl-3-methyl octane}\]

(A) is 5-isopropyl-3-methyloctane
(B) is 5-isopropyl-3-methylpentane
(C) is 3-methyl-3-ethylpentane
(D) is 4-ethyl-3-methyloctane
(E) is 2,3-dimethylheptane

25. The molecular formula of

\[C_7\text{H}_8\]

(A) is C_7H_{14}
(B) is C_6H_{14}
(C) is C_7H_6
(D) is C_7H_8
(E) is C_6H_8
26. A structure of arabinose is shown below. The arabinose shown has:

\[ \text{Structure of arabinose} \]

(A) one chiral carbon
(B) two chiral carbons
(C) three chiral carbons
(D) four chiral carbons
(E) five chiral carbons

27. Methyl salicylate (the compound that smells like wintergreen) contains:

\[ \text{Structure of methyl salicylate} \]

(A) an alcohol and a ketone.
(B) an alcohol and an ether.
(C) an alcohol and an ester.
(D) an alcohol and an amide.
(E) an alcohol and an aldehyde.
28. Complete the following condensation reaction:

\[
\begin{align*}
\text{C} & \quad \text{H}_2\text{O} \quad \text{is lost} \\
\text{O} & \quad \text{OH} + \text{H}\text{N} \\
\text{C} & \quad \rightarrow \\
\text{N} & \quad \text{H} \\
\end{align*}
\]

(A) \quad \text{(A)} \\

(B) \quad \text{(B)} \\

(C) \quad \text{(C)} \\

(D) \quad \text{(D)} \\

29. Carnosine is highly concentrated in muscle and brain tissues. Carnosine is a dipeptide of which two amino acids?

\[
\begin{align*}
\text{H} & \quad \text{H} \\
\text{H} & \quad \text{O} \\
\text{H} & \quad \text{N} \\
\text{C} & \quad \text{C} \\
\text{N} & \quad \text{C} \\
\text{C} & \quad \text{O} \\
\end{align*}
\]

\[
\begin{align*}
\text{CH}_2 & \quad \text{CH}_2 \\
\text{CH}_2 & \quad \text{CH}_2 \\
\text{O} & \quad \text{C} \\
\text{H} & \quad \text{N} \\
\text{H} & \quad \text{H} \\
\end{align*}
\]

\[
\begin{align*}
\text{CH}_2 & \quad \text{H} \\
\text{CH}_2 & \quad \text{H} \\
\text{C} & \quad \text{N} \\
\text{H} & \quad \text{N} \\
\text{C} & \quad \text{H} \\
\end{align*}
\]

(A) proline and glutamic acid \\
(B) alanine and glycine \\
(C) glutamine and tyrosine \\
(D) histidine and tyrosine \\
(E) glutamine and histidine
30. Consider the fat molecule below. Which of the following is false?

(A) This fat is an omega-6 fat
(B) This fat contains 3 cis- and 2 trans- bonds
(C) This fat is an omega-3 fat
(D) This fat contains three ether groups
(E) One carbon chain is saturated

31. Complete the following addition reaction:

(A) [Diagram of a molecule with a carbon atom marked as having no H]
(B) [Diagram of a molecule with a H and Br bonded to a carbon atom]
(C) [Diagram of a molecule with a Br bonded to a carbon atom]
(D) [Diagram of a molecule with a Br bonded to a carbon atom]
32. The organic product of benzene and in the presence of AlCl₃ is:

(A) [Chemical structure]

(B) [Chemical structure]

(C) [Chemical structure]

(D) [Chemical structure]

33. Well, well, well... CH 123 is over. Time to...

(A) head home, work a summer job, and try to forget about chiral carbons.

(B) cry; possibly for hours.

(C) two words: Blackberry and Skittles

(D) refurnish my room to resemble Gilbert 124. I plan on reliving general chemistry every day of my life; for it has been a breathtaking experience I cannot live without.

(E) cut my toe nails.

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

Questions 1 through 32 have four points attached (128 total). Any response to Question 33 will receive full credit (2 Points total); even no response. The point total for this exam is 130 points. See the grade sheet for grade computation details. Final exam keys, scores, and course grades will be posted on the CH 123 website as they become available. Have a great life. Go out there and do some really cool stuff :(