INSTRUCTIONS:

Use a soft, #2 pencil. Your marks must be dark to be counted correctly.

Write your perm number and **bubble in your perm number.** Correct perm = 2 points!

Bring a **CALCULATOR**

1. Predict how the following reaction at equilibrium will shift by the affect of an increase in volume.

   \[ \text{2 NCl}_3 \ (g) \rightleftharpoons \text{N}_2 \ (g) \ + \ 3 \text{Cl}_2 \ (g) \]

   a) left
   b) right
   c) no shift

   *Answers are included at the end of the quiz.*

2. Consider the following three equilibria occurring simultaneously in solution.

   \[
   \begin{align*}
   \text{Ca}^{2+} \text{(aq)} + \text{C}_2\text{O}_4^{2-} \text{(aq)} & \rightleftharpoons \text{CaC}_2\text{O}_4 \text{(s)} \quad (1) \\
   \text{H}_2\text{C}_2\text{O}_4 \text{(aq)} & \rightleftharpoons \text{H}^+ \text{(aq)} + \text{HC}_2\text{O}_4^- \text{(aq)} \quad (2) \\
   \text{HC}_2\text{O}_4^- \text{(aq)} & \rightleftharpoons \text{H}^+ \text{(aq)} + \text{C}_2\text{O}_4^{2-} \text{(aq)} \quad (3)
   \end{align*}
   \]

   If NaOH is added to the solution, will the amount of CaC\(_2\)O\(_4\) (s) precipitate increase or decrease or stay the same

   a) Increase
   b) Decrease
   c) Stay the same

3. A solution is prepared by adding 20.0 mL of 0.10 M HCl to 30.0 mL of 0.20 M HNO\(_3\). Calculate the concentration of H\(^+\) in this solution. Both HCl and HNO\(_3\) are strong acids.

   a) 0.04 M
   b) 0.12 M
   c) 0.16 M
   d) 0.30 M
   e) 0.14 M

4. Calculate the pH of a 0.10 M HNO\(_2\) solution. (\(K_a = 4.6 \times 10^{-4}\) for HNO\(_2\))

   a) 5.3
   b) 1.0
   c) 1.7
   d) 2.2
   e) 8.7

5. A 0.1 M aqueous solution of the salt NaNO\(_3\) is made. Will the solution be acidic, basic or neutral?

   a) acidic
   b) basic
   c) neutral
6. A 0.1 M aqueous solution of the salt NaHCO₃ is made. Will the solution be acidic, basic or neutral?
   a) acidic
   b) basic
   c) neutral

7. A 0.1 M aqueous solution of the salt NH₄NO₃ is made. Will the solution be acidic, basic or neutral?
   a) acidic
   b) basic
   c) neutral

8. Consider a 0.1 M NaNO₂ solution and a 0.1 M NaCN solution. Which solution will have the lower pH?
   a) 0.1 M NaNO₂
   b) 0.1 M NaCN
   c) Neither; the solutions have the same pH

9. List the major species present in a 0.25 M solution of CH₃COOH.
   a) CH₃COOH, CH₃COO⁻, H⁺, H₂O
   b) CH₃COO⁻, H⁺, H₂O
   c) CH₃COO⁻, H⁺, OH⁻, H₂O
   d) CH₃COOH, H₂O
   e) CH₃COOH, CH₃COO⁻, H⁺, OH⁻, H₂O

<table>
<thead>
<tr>
<th>Acid</th>
<th>HA</th>
<th>A⁻</th>
<th>( K_a )</th>
<th>p ( K_a )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrochloric</td>
<td>HCl</td>
<td>Cl⁻</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitric</td>
<td>HNO₃</td>
<td>NO₃⁻</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydronium ion</td>
<td>H₃O⁺</td>
<td>H₂O</td>
<td>1</td>
<td>0.0</td>
</tr>
<tr>
<td>Hydrofluoric</td>
<td>HF</td>
<td>F⁻</td>
<td>6.6 x 10⁻¹⁴</td>
<td>3.18</td>
</tr>
<tr>
<td>Nitrous</td>
<td>HNO₂</td>
<td>NO₂⁻</td>
<td>4.6 x 10⁻¹⁴</td>
<td>3.34</td>
</tr>
<tr>
<td>Acetic</td>
<td>CH₃COOH</td>
<td>CH₃COO⁻</td>
<td>1.76 x 10⁻⁵</td>
<td>4.75</td>
</tr>
<tr>
<td>Carbonic (1)</td>
<td>H₂CO₃</td>
<td>HCO₃⁻</td>
<td>4.3 x 10⁻⁷</td>
<td>6.37</td>
</tr>
<tr>
<td>Hydrocyanic</td>
<td>HCN</td>
<td>CN⁻</td>
<td>6.17 x 10⁻¹⁰</td>
<td>9.21</td>
</tr>
<tr>
<td>Ammonium ion</td>
<td>NH₄⁺</td>
<td>NH₃</td>
<td>5.6 x 10⁻¹⁰</td>
<td>9.25</td>
</tr>
<tr>
<td>Carbonic (2)</td>
<td>HCO₃⁻</td>
<td>CO₃²⁻</td>
<td>4.8 x 10⁻¹¹</td>
<td>10.32</td>
</tr>
<tr>
<td>Water</td>
<td>H₂O</td>
<td>OH⁻</td>
<td>1.0 x 10⁻¹⁴</td>
<td>14.00</td>
</tr>
</tbody>
</table>

\[ \text{pH} = - \log [H⁺] \quad [H⁺] = 10^{-\text{pH}} \]
\[ K_w = 1 \times 10^{-14} \quad \text{at} \quad 25°C \quad K_w = [OH⁻][H⁺] \quad K_w = K_aK_b \]

**ANSWERS:**
1. b  
2. a  
3. c  
4. d  
5. b  
6. b  Why basic? HCO₃⁻ is amphoteric. Compare the value of \( K_b \) to \( K_a \)  
7. a  
8. a  
9. d  Compare the value of \( K_b \) for NO₂⁻ to the value of \( K_b \) for CN⁻. Smaller \( K_b \) => less OH⁻ => lower pH