Tables of data for the problems are attached to the equation sheets.

The temperature is $25 \, ^\circ\text{C} = 298.15 \, \text{K}$ for all of the problems.

1. (10 points)  
   Calculate the pH of a buffer solution prepared by adding sufficient water to 0.02 moles of formic acid (call it HFo) and 0.01 moles of sodium formate (NaFo) to make 1 liter of solution. Activity coefficients may be ignored.

2. (10 points)  
   In the estimation of the pH at the end point of a titration of an acid with a base, the first step is to estimate the concentration of the resulting salt solution. Calculate the concentration of NH$_4$Cl in the solution produced at the end point of the titration of 25.0 mL of 0.016 M NH$_3$ solution with 0.020 M HCl solution.

3. (10 points)  
   The solubility of Mg(OH)$_2$ is $1.1 \times 10^{-7} \, \text{mol L}^{-1}$ in a solution in which the pOH = 2.0. Estimate the solubility product constant $K_s$ for Mg(OH)$_2$. Activity coefficients may be ignored.

4. (10 points: 5, 5)  
   An external voltage source is used to force a total charge of 0.40 faradays through a Cu$^{2+}$(aq) solution in an electrolytic cell depositing Cu(s) (atomic mass = 63.6 g mol$^{-1}$) in the process.
   a) How many grams of Cu(s) were deposited in the process?
   b) If the electrical current through the cell was 2.0 amperes, how many seconds were required to pass 0.40 faradays?
5. (20 points) A problem of this type will not be on the third examination, Fall, 1996.
Consider the reaction between selenious acid and iodide ion in acid solution

\[ \text{H}_2\text{SeO}_3(aq) + 6 \text{I}^-(aq) + 4 \text{H}^+(aq) = \text{Se(s)} + 2 \text{I}_3^-(aq) + 3\text{H}_2\text{O}(l) \]

The rate law for this reaction is of the form \( r = \frac{\text{d}[\text{H}_2\text{SeO}_3]}{\text{dt}} = k[\text{H}^+][\text{H}_2\text{SeO}_3]^m[\text{I}^-]^n \).

The following rates were obtained for several experiments in which \([\text{H}^+] = 0.02 \text{ mol L}^{-1}\):

<table>
<thead>
<tr>
<th>Reaction</th>
<th>[H\textsubscript{2}SeO\textsubscript{3}]/mol L\textsuperscript{-1}</th>
<th>[I\textsuperscript{-}]/mol L\textsuperscript{-1}</th>
<th>r/mol L\textsuperscript{-1} s\textsuperscript{-1}</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>0.71 \times 10\textsuperscript{-4}</td>
<td>0.030</td>
<td>0.40 \times 10\textsuperscript{-6}</td>
</tr>
<tr>
<td>(2)</td>
<td>2.50 \times 10\textsuperscript{-4}</td>
<td>0.030</td>
<td>1.40 \times 10\textsuperscript{-6}</td>
</tr>
<tr>
<td>(3)</td>
<td>0.71 \times 10\textsuperscript{-4}</td>
<td>0.090</td>
<td>10.5 \times 10\textsuperscript{-6}</td>
</tr>
<tr>
<td>(4)</td>
<td>2.50 \times 10\textsuperscript{-4}</td>
<td>0.090</td>
<td>36.0 \times 10\textsuperscript{-6}</td>
</tr>
</tbody>
</table>

a) Determine the order of the reaction with respect to H\textsubscript{2}SeO\textsubscript{3} and I\textsuperscript{-}.
b) Use the data for reaction (1) to determine the rate constant. Be sure to specify the units (do not forget the contribution from [H\textsuperscript{+}]).

6. (10 points)
a) Use the table of reduction half reactions attached to the equation sheet to write a balanced chemical equation and predict the direction of reaction for a mixture made up from all of the following in approximately unit activity in water solution: S\textsubscript{2}O\textsubscript{8}\textsuperscript{2-}, SO\textsubscript{4}\textsuperscript{2-}, Cr\textsubscript{2}O\textsubscript{7}\textsuperscript{2-}, H\textsuperscript{+}, Cr\textsuperscript{3+}, H\textsubscript{2}O.
b) Write the balanced chemical equation for the expected reaction if a strip of metallic lead is dipped into a solution of Ni\textsuperscript{2+} and Cu\textsuperscript{2+} in water (a copy of the metal activity series is attached to the equation sheet).

7. (30 points: 6, 6, 6, 6, 6)
Consider the following galvanic cell:

\[ \text{Ag(s)} | \text{AgCl(s)} | \text{CuCl}_2(aq) | \text{Cu(s)} \]
a) Write reactions for the right and left electrodes and write the cell reaction.
b) Determine \( E^0 \) for this cell.
c) Determine the activity quotient \( Q \) for this cell if the concentration of CuCl\textsubscript{2} is 0.01 M (ignore activity coefficients; use the equation for the cell reaction in part (a)).
d) Determine \( E \) for this cell if the concentration of CuCl\textsubscript{2} is 0.01 M (ignore activity coefficients; use the results of parts (b) and (c)).
e) Identify the cathode, anode, and direction of flow of electrons in the outer circuit for the experimental conditions in part (d).