1. (5 points) Indicate whether each of the following statements is true or false:

T     F
__    __A catalyst can change the equilibrium constant of a reaction.
__    __A catalyst can change the activation energy of a reaction.
__    __Chemical equilibrium occurs when opposing reactions proceed at equal rates.
__    __A system is always at equilibrium when the reaction quotient equals the equilibrium constant.
__    __A Lewis acid can never act as a Bronsted-Lowry acid.
__    __Increasing the concentration of a weak acid increases its percent ionization.
__    __The equivalence point of a weak acid titrated against a strong base is basic.
__    __All indicators change color when a solution is at neutrality.
__    __Ammonia and ammonium chloride can be used to construct a buffer solution.
__    __Titration of an acid requires a base solution with a known concentration.

2. (5 points) Briefly define each of the following terms:

Half-life

Instantaneous rate

Reaction intermediate

Amphoteric

Buffer solution
3. (10 points) State whether an aqueous solution of each of the following compounds would be acidic, basic or neutral.

CH$_3$COOH

KBrO$_4$

Fe(NO$_3$)$_3$

(NH$_4$)$_3$PO$_4$

Ca(ClO)$_2$

4. (10 points) Consider the reaction

\[ 2 \text{ClO}_2(aq) + 2 \text{OH}^- (aq) \rightarrow \text{ClO}_3^- (aq) + \text{ClO}_2^- (aq) + \text{H}_2\text{O}(l) \]

The following rate data were collected:

<table>
<thead>
<tr>
<th>Experiment</th>
<th>[ClO$_2$]</th>
<th>[OH$^-$]</th>
<th>Initial rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.060 M</td>
<td>0.030 M</td>
<td>0.0248 M/s</td>
</tr>
<tr>
<td>2</td>
<td>0.020 M</td>
<td>0.030 M</td>
<td>0.00276 M/s</td>
</tr>
<tr>
<td>3</td>
<td>0.020 M</td>
<td>0.090 M</td>
<td>0.00828 M/s</td>
</tr>
</tbody>
</table>

Write the rate law and give the rate constant for this reaction.
5. (10 points) For the reaction
\[ A + 2B \rightarrow E \]

A. Give the rate law if the mechanism is:
\[ 2A + B \rightarrow C \quad \text{(slow)} \]
\[ B + C \rightarrow D + A \quad \text{(fast)} \]
\[ D \rightarrow E \quad \text{(fast)} \]

B. Give the rate law if the mechanism is:
\[ 2A + B \rightarrow C \quad \text{(fast)} \]
\[ B + C \rightarrow D + A \quad \text{(slow)} \]
\[ D \rightarrow E \quad \text{(fast)} \]
6. (10 points) Consider the reaction

\[ 2 \text{HCl}(g) \rightleftharpoons \text{Cl}_2(g) + \text{H}_2(g) \]

A. What is the equilibrium constant expression for this reaction?

B. If a flask at equilibrium contains 0.0114M HCl, 0.0931M Cl\(_2\) and 0.0154M H\(_2\), what is the numerical value of \(K_c\)?

C. For the conditions above, what is the numerical value of \(K_p\)?

D. Give the numerical value of \(K_c\) for the reaction \(\text{Cl}_2(g) + \text{H}_2(g) \rightleftharpoons 2 \text{HCl}(g)\).
7. (10 points)

A. Write the equilibrium constant expression for the following reaction:

\[
\text{NiCO}_3(s) + 2 \text{H}^+ (\text{aq}) \rightleftharpoons \text{Ni}^{2+} (\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})
\]

B. How will the addition of a solution of hydrochloric acid to the system affect the pressure of \( \text{CO}_2(\text{g}) \) above the sample? Explain your answer.
8. (10 points) Calculate the pH of the following solutions:

   A. A 0.10M solution of potassium hydroxide:

   B. A 0.10 M solution of acetic acid:

   C. The solution formed by the addition of 10.0 mL of 0.10M potassium hydroxide to a 50.0 mL sample of 0.10M acetic acid:
9. (15 points)

A. You want to make a buffer solution of pH=3.5. How many grams of sodium nitrite should be added to a 0.500L sample of 0.10M nitrous acid? You may neglect the volume of solid acid added.
B. The pH of a sample of hydrochloric acid is 0.0. What is the pH of the system if 5.00mL of this acid is added to 0.500L the buffer you prepared in part A of this problem? Account for the volume of the acid in this problem.
10. (15 points) Aliens from the planet Zarkox are found to have a circulatory fluid analogous to blood. Experiments detect a 1.13M concentration of HF in its unionized form, and a 0.82M concentration of the fluoride ion.

A. Calculate the pH of Zarkox blood.

B. State in words the significance of the observed concentrations with respect to Zarkox biochemistry. (Hint: How does this system resemble human blood?)