I. (3 pts. each) Match the following terms and definitions.

1. _______ When the amount of added titrant is chemically equivalent to the amount of analyte in the sample.

2. _______ Solution consisting of a conjugate acid/base pair found when a weak acid is titrated with a strong base.

3. _______ Ion or molecule that forms a covalent bond with a cation or metal by donating a pair of electrons that are shared by the two.

4. _______ Weak organic acid or base added to the analyte solution to give an observable physical change at or near the equivalence point.

5. _______ Compound whose purity has been established by chemical analysis and serves as a reference.

6. _______ Method used to determine the concentration of analytes that are themselves acids or bases.

7. _______ pKa ± 1

A. Ligand  
B. Indicator  
C. Chelate  
D. Coulometric Titration  
E. Secondary Standard  
F. Neutralization Titration  
G. Indicator pH range  
H. Buffer  
I. Equivalence Point  
J. Primary Standard

II. (3 pts) How many binding sites does EDTA have?_______

(3 pts) How many Cu^{2+} bind/molecule EDTA?_______
III. (8 pts) Titration of 50.0 mL of 0.0521 M $\text{Na}_2\text{C}_2\text{O}_4$ requires 38.71 mL of potassium permanganate:

$$2\text{MnO}_4^- + 5 \text{C}_2\text{O}_4^{2-} + 16\text{H}^+ \rightarrow 2\text{Mn}^{2+} + 10 \text{CO}_2 (g) + 8 \text{H}_2\text{O}$$

Calculate the molarity of the KMnO$_4$ solution.

IV. (8 pts) Calculate the pH of a solution that results from mixing 20.0 mL 0.200 M HCl with 25 mL 0.50 M NaOH.

V. (10 pts) What is the pH of a solution that is prepared by dissolving 9.20 g lactic acid (90.08 g/mol) and 11.5 g of sodium lactate (112.06 g/mol) in water and diluting to 1L. $K_a = 1.38 \times 10^{-4}$. 


VI. (9 pts) A 0.5843 g sample of plant food was analyzed for its nitrogen content by the Kjehldahl method. The liberated NH$_3$ was collected in 50 mL 0.1062 M HCl. The excess acid requires an 11.89 mL back titration with 0.0925 M NaOH. Express the results in terms of % nitrogen and % protein.

VII. (10 pts) Calculate the pH of a solution that is 0.240 M H$_3$PO$_4$ and 0.480 M NaH$_2$PO$_4$. $K_a = 7.11 \times 10^{-3}$. 
VIII. (8 pts) List four requirements of primary standards.

IX. (5 pts each) Write mass balance equations for a solution that is:
1. 0.100 M in HNO\(_2\) and 0.0500 M in NaNO\(_2\).

2. A solution that is saturated with MgCO\(_3\).

X. (5 pts each) Write charge balance equations for:
1. A solution saturated with MgCO\(_3\).

2. A solution that is 0.10 M in Na\(_2\)HPO\(_4\).