Acid-Base Titration Assignment

Introduction:

Titration is a process of neutralization whereby a titrant (a solution of known concentration) is delivered into an analyte (unknown solution) until the unknown solution is completely neutralized. This will allow information about the unknown solution to be determined. An indicator is (often) a weak acid that is placed into the unknown solution to determine the endpoint of the titration (the pH at which the indicator changes color). The equivalence point of the titration is the point when the moles of H^+ are equal to the moles of OH^- in a titration. The progress of an acid-base titration is often monitored by plotting the pH of the solution being analyzed as a function of the amount of titrant added. The graph produced is called a titration curve.

Types of Titrations:

1. Strong Acid / Strong Base: pH at equivalence point = 7
2. Weak Acid / Strong Base: pH at equivalence point >7
3. Strong Acid / Weak Base: pH at equivalence point <7

*Note: weak acid / weak base titrations are too complicated and are almost never carried out.

Indicators:

Indicator – a substance (often a weak acid) that has distinctively different colors in acidic and basic media. Not all indicators change color at the same pH, so the choice of indicator for a particular titration depends on the strength of the acid and base. Choose an indicator whose end point range lies on the steep part of the curve.

Indicators and Le Chatelier's Principle

$$HIn(aq) \leftrightarrow H^+(aq) + In^-(aq)$$

In the presence of an acid (supplier of H^+), the $[H^+]$ increases and the reaction shifts reverse.

In the presence of a base (supplier of OH^- ions that will react with the H^+ in solution to form water), the $[H^+]$ decreases and the reaction shifts forward.

The pH ranges of some common indicators:

Indicator	pH range	color in acid	color in base
methyl violet	0.0-1.6	yellow	blue
methyl yellow	2.9-4.0	red	yellow
bromophenol blue	3.0-4.6	yellow	blue
methyl orange	3.2-4.4	red	yellow
methyl red	4.8-6.0	red	yellow
litmus	5.5-8.0	red	blue
bromothymol blue	6.0-7.6	yellow	blue
phenol red	6.6-8.0	yellow	red
phenolphthalein	8.2-10.6	colorless	red
thymolphthalein	9.4-10.6	colorless	blue
alizarin yellow	10.0-12.0	yellow	red

Objective: to analyze the similarities and differences between two different types of titrations/titration curves.

Part 1:

A student conducted the following experiment in the lab:

50.00 mL of nitric acid (of unknown concentration) was pipetted into a 150 mL Erlenmeyer flask and an indicator was added. The pH of this solution was recorded using a digital pH meter. While the probe of the pH meter was submerged in the acid solution, 0.1 mol/L NaOH (a strong base) was added gradually to the Erlenmeyer flask from a buret. The contents of the flask were stirred continuously and the pH was recorded after every 2.0 mL of NaOH had been added.

Data Collected:

Volume of NaOH added (mL)	pH
0.0	1.00
10.0	1.18
20.0	1.37
40.0	1.95
45.0	2.28
48.0	2.69
49.0	3.00
50.0	7.00
51.0	11.00
55.0	11.68
60.0	11.96
80.0	12.36
100.0	12.52

a) The chemicals involved in the titration are NaOH and HNO_3. Both are strong electrolytes. Predict the shape of the titration curve that would be obtained from the data above. Also predict what the pH at the equivalence point will be.

b) Write a symbolic equation for this chemical reaction.

c) Prepare a plot of pH as a function of the volume of NaOH added. Be sure to label your axes and include an appropriate title.

d) Explain at the molecular level why the pH increases as NaOH is added to HNO_3.

e) Use this graph to determine the equivalence point. Clearly **mark** and **label** this point on your graph.

f) Draw a molecular level representation of the Erlenmeyer flask at the equivalence point.

g) What is the volume of NaOH at the equivalence point?

h) What is the pH at the equivalence point?

i) What does the value for pH at the equivalence point tell you about the strength of the acid?

j) Calculate the concentration of the nitric acid solution.

k) Using the chart provided in the introduction, what would have been a suitable indicator for this titration?

Part 2:

A student conducted the following experiment in the lab.

50.00 mL of acetic acid (of unknown concentration) was pipetted into a 150 mL Erlenmeyer flask. Indicator was added and the pH of the solution was recorded. 0.1 M NaOH (a strong base) was added to the Erlenmeyer flask from a buret. The contents of the flask were continuously stirred and the pH was recorded every 2 mL using a pH meter.

Data Collected:

Volume of NaOH added (mL)	pH
0.0	2.87
10.0	4.14
25.0	4.74
40.0	5.35
50.0	8.72
60.0	11.96
75.0	12.30

a) The chemicals involved in the titration are NaOH (a strong electrolyte) and CH_3COOH (a weak electrolyte). Predict the shape of the titration curve that would be obtained from the data above. Also predict what the pH at the equivalence point will be.

b) Write a symbolic equation for this reaction.

c) Prepare a plot of pH as a function of the volume of NaOH added. Be sure to label your axes and include an appropriate title.

d) Explain at the molecular level why the pH increases as NaOH is added to CH_3COOH.

e) Use this graph to determine the equivalence point. Clearly **mark** and **label** this point on your graph.

f) Draw a molecular level representation of the Erlenmeyer flask at the equivalence point.

g) What is the volume of NaOH at the equivalence point?

h) What is the pH at the equivalence point?

i) What does the value for pH at the equivalence point tell you about the strength of the acid?

j) Calculate the concentration of the acetic acid solution.

k) Using the chart provided in the introduction, what would have been a suitable indicator for this titration?

l) Compare the two graphs you obtained in parts 1 and 2 above. Examine them closely and carefully. List and explain the similarities and differences between these two graphs. Pay particular attention to where the curve begins and the equivalence point.