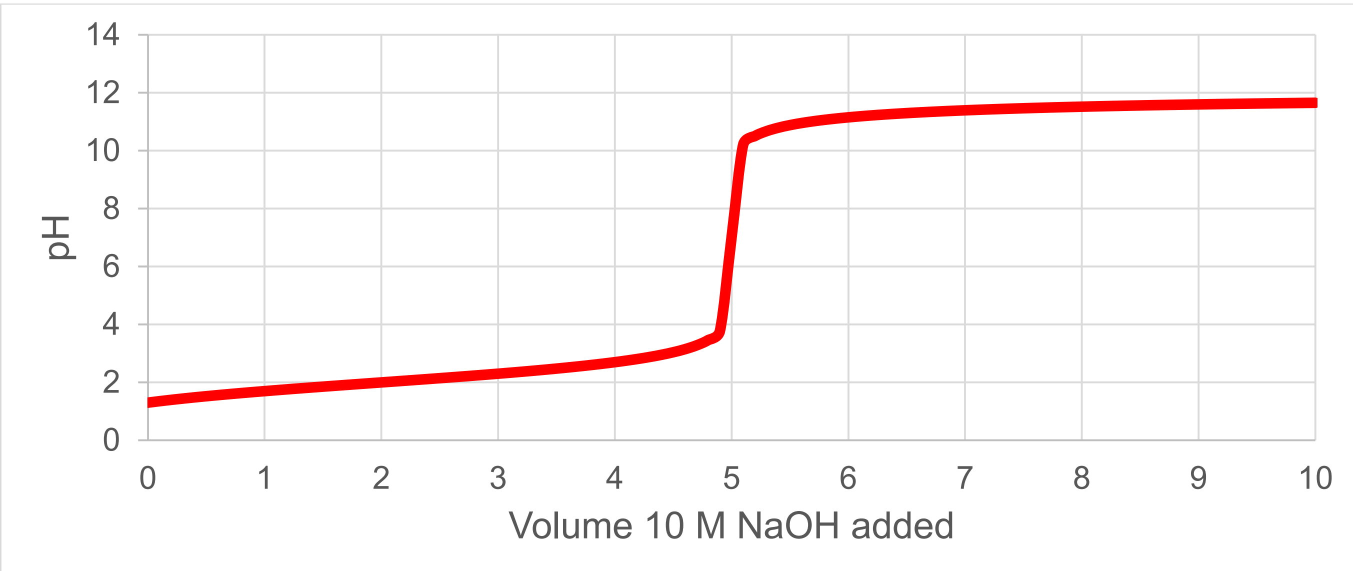
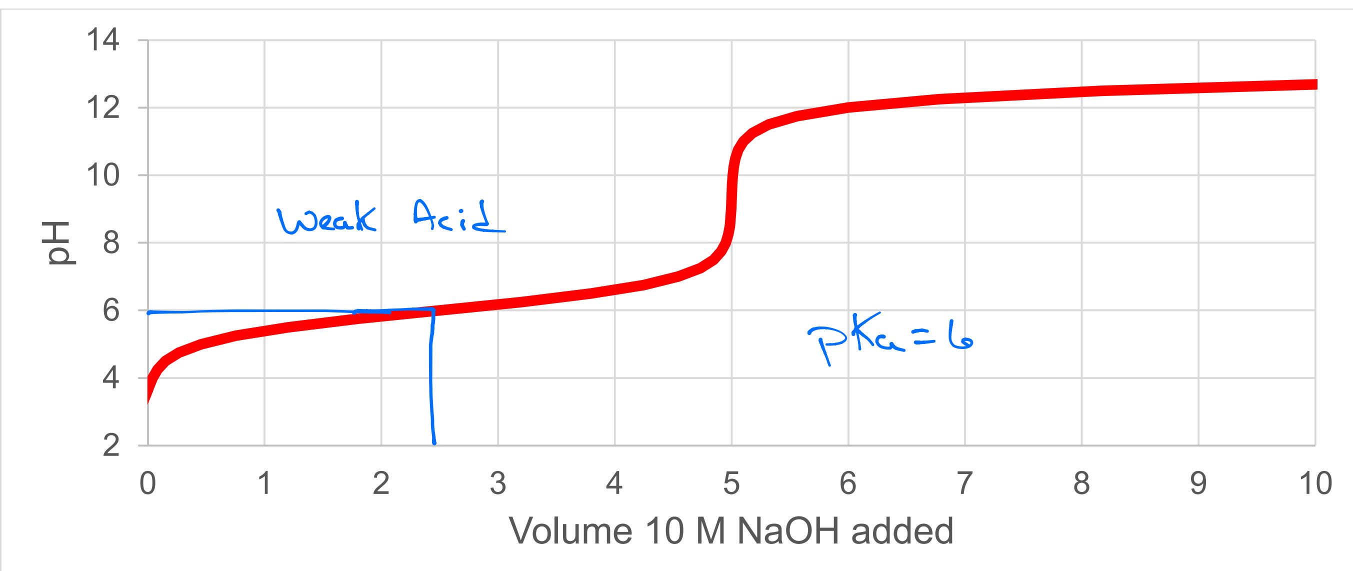
Below, you see two titration curves of 10 M NaOH into 1 L of 50 mM acid. For each of the curves, answer these questions:

1. Is the acid strong or weak?

2. If this is a weak acid, what is the pKa?

3. Determine each of the following:
    a. Initial pH
    b. pH at the ½ equivalence point
    c. pH at the equivalence point





A common buffer used in biochemistry experiments is called "Tris" and it has a pKa of 8.1. Answer each of the following questions about this buffer.

4. What is the maximum and minimum pH that can be buffered by Tris?

   9.1 7.1

5. Which form of the buffer (A- or HA) is present at higher concentration at pH 8.6?

   pH > pKa so more basic more A^-

6. Consider a 500 mL solution that contains 50 mM Tris acid (HA) and 25 mM Tris base (A-)
   a. What is the pH of this solution?

   $pH = 8.1 + \log \frac{25\ mM}{50\ mM} = 7.8$

   b. Calculate the pH if 2.5 mL of 1.6 M HCl is added.

   $0.0025\ L \cdot \frac{1.6\ mol}{L} = 0.004\ mol\ HCl$

   A^-: $0.5\ L \cdot \frac{0.025\ mol}{L} = 0.0125\ mol$

   HA: $0.5\ L \cdot \frac{0.05\ mol}{L} = 0.025\ mol$

   $A^- + HCl \rightarrow HA + Cl^-$

	A^-	HCl	HA
I	0.0125	0.004	0.025
C	−0.004	−0.004	+0.004
E	0.0085	∅	0.029

   $pH = 8.1 + \log \frac{0.0085}{0.029} = 7.567$

7. In lab, you find a 250 mL solution of 50 mM Tris base (the basic form of Tris; call is A- if it helps you) and a 1 M solution of nitric acid. How can you make a Tris buffer at pH 7.5? Be specific – tell me exactly what volume of nitric acid that you need to add to the Tris base solution.

Here's whats going to happen:

$A^- + HNO_3 \rightarrow HA + NO_3^-$

	A^-	HNO_3	HA
I	I	x	∅
C	−x	−x	+x
E	I−x	∅	x

our goal is to figure out how many mols of HNO_3 (x) to add

$A^- = I - x$ $x = HA$

I = moles A^- @ beginning

$0.25\ L \cdot \frac{0.05\ mol}{L} = 0.0125\ mol$

$7.5 = 8.1 + \log \frac{A^-}{HA}$

$A^- = 0.251\ HA$

$I - x = 0.251x$

$0.0125 - x = 0.251x$

$0.0125 = 0.251x + x$

$0.0125 = (1 + 0.251)x$

$x = 0.00999\ mol\ HNO_3 \cdot \frac{L}{1\ mol} = 0.00999\ L\ HNO_3$

To make this buffer, add ~10 mL of 1M HNO_3

Strong Acid

3a. 50 mM Strong Acid → 50 mM H_3O^+ $pH = -\log 0.05 = 1.3$

3b. moles Acid: $\frac{1L \mid 0.05 mol}{L} = 0.05$ mol

½ eq. Pt. $0.05(\frac{1}{2})$ moles OH^- added $= 0.025$ mol OH^-

0.025 moles acid left

$\frac{0.025 mol \mid L}{\mid 10 mol} = 0.0025 L$

$[H_3O^+] = \frac{0.025 mol}{1.0025 L} = 0.02494$ $pH = -\log 0.02494 = 1.60$

3C. Strong Acid / strong base titration $pH = 7$

Weak acid

3a. $[HA] = 50 mM$ $pKa = 10^{-6}$

$HA + H_2O \rightleftharpoons A^- + H_3O^+$

	HA	A^-	H_3O^+
I	0.05	0	0
C	$-x$	$+x$	$+x$
E	$0.05-x$	x	x

$$10^{-6} = \frac{x^2}{0.05-x}$$

$$0 = x^2 + 10^{-6}x - 5\times10^{-8}$$

... quadratic ...

$x = 2.23\times10^{-4}$ $pH = -\log 2.23\times10^{-4} = 3.65$

3b. ½ Eq Pt $pH = pKa = 6$

3C. Eq. Pt. (5mL NaOH added)

$HA + OH^- \rightarrow A^- + H_2O$

	HA	OH^-	A^-	H_2O
I	0.05 mol	0.05 mol	∅	∅
C	-0.05	-0.05	$+0.05$	
E	∅	∅	0.05 mol	

$\frac{0.05 mol}{1.005 L}$ A^- created (weak acid)

$A^- + H_2O \rightleftharpoons HA + OH^-$

	A^-	HA	OH^-
I	0.0498	∅	∅
C	−x	+x	+x
E	0.0498 − x	x	x

$pK_b = 14 - pK_a = 8$

$10^{-8} = \frac{x^2}{0.0498 - x}$ take short cut

$10^{-8} = \frac{x^2}{0.0498}$ $x = [OH^-] = 2.23 \times 10^{-5}$ M

$pOH = -\log 2.23 \times 10^{-5} = 4.65$

$pH = 14 - pOH = 9.34$