• AP Chemistry

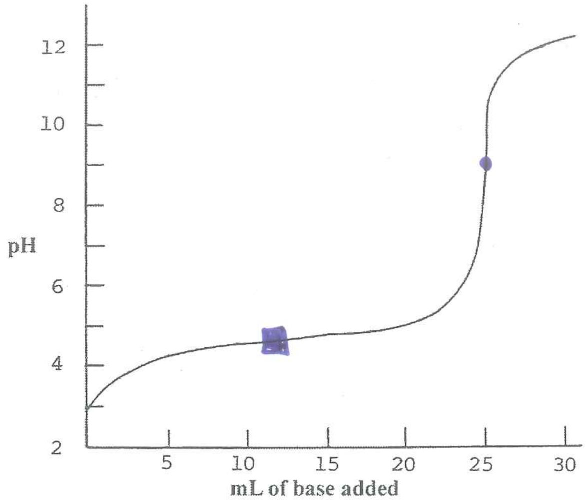
Name CALVIN
Period ___ Date ___/___/___

15 • Acid-Base Reactions

CALCULATIONS

Information from the Curve:

There are several things you can read from the titration curve itself. Consider this titration curve.



1. This is a weak (strong/weak) acid titrated with a strong base. The acid is mono (monoprotic/diprotic). How would the other strength of acid look?

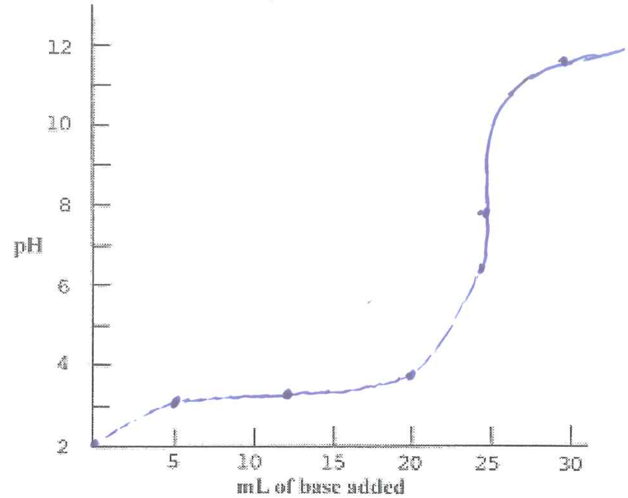
2. Place a dot (•) on the curve at the equivalence point. The pH at the equivalence point is 9. Choose a good indicator for this titration from Figure 17.11 on page 810 of your textbook.

   phenolphthalein

3. What volume of base was used to titrate the acid solution? 25 mL

4. Place a box (■) on the curve where the pH of the solution = the pK_a of the acid. ½ way to 25mL
   What is the pH at this point? 4.8
   What is the pK_a of the acid? 4.8
   What is the K_a of the acid? 1.6×10^{-5}

Calculations knowing the Acid:



5. Hydrofluoric acid, HF, has a $K_a = 7.2 \times 10^{-4}$. Calculate the pH of 10.0 mL of a 0.050 M solution of HF. Plot this point on the axes.

   pH=2.25

6. A 0.020 M solution of NaOH is used for the titration. What volume will be needed to reach the equivalence point?

   $V \cdot M = V \cdot M$ 25mL

7. Write the net reaction for the neutralization of a solution of HF with a solution of NaOH.

   $HF + OH^- \rightarrow H_2O_{(l)} + F^-$

8. Calculate the moles of F^- at the equivalence point. What is the total volume? .035 L
   The $[F^-]$ at the equivalence point is 0.0143 M

9. Calculate the pH of the solution at the equivalence point. Use this information and the answer to question 6 to plt the equivalence point on your graph. Choose a good indicator for this titration from Figure 17.11 on page 810 of your textbook.

   pH=7.65 at 25mL base

10. What is the pH halfway to the equivalence point? Plot this point on your graph.

pH = pKa = 3.14 at 12.5 mL

11. How many moles of HF are in the original 10.0 mL sample of HF? 0.00050 mol HF

12. When only 5.0 mL of 0.020 M NaOH has been added, calculate the moles of HF left and F^- produced.

	HF	OH^-	H_2O	F^-
i	.00050	.00010	-------	0
c	−0.00010	−0.00010	-------	+0.00010
e	.00040	0	-------	.00010 moles

Total volume = 15 mL

13. Use the Henderson-Hesselbach equation or an icebox to calculate the pH when 5.0 mL of base has been added. Plot this point on your graph.

pH = 2.69 At 5 mL base

14. When 20.0 mL of 0.020 M NaOH has been added, calculate the moles of HF left and F^- produced.

	HF	OH^-	H_2O	F^-
i	.00050	.00040	-------	0
c	−.00040	−.00040	-------	+0.00040
e	.00010	0	-------	.00040

total vol = 30. mL

15. Use the Henderson-Hesselbach equation or an icebox to calculate the pH when 20.0 mL of base has been added. Plot this point on your graph.

pH = 3.77 at 20 mL Base

16. When 30.0 mL of base is added, how many moles of OH^- is in excess? .00010 mol

The total volume is .040 L.

$[OH^-]$ = .0025 M

pOH = 2.60 pH = 11.40

Plot this point on your graph.

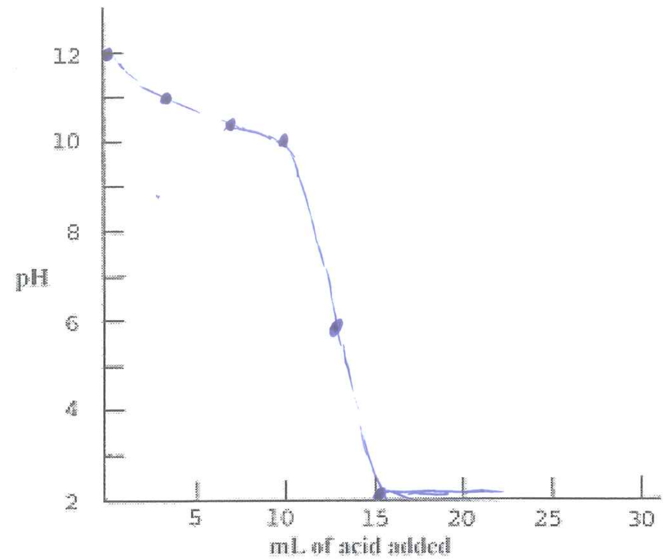
pH = 11.40 at 30 mL of base

17. Sketch the titration curve on your graph.

Weak Base-Strong Acid Curve:

A 20.0 mL sample of 0.10 M CH_3NH_2 (methyl amine) is titrated with 0.15 M HCl. The K_b for $CH_3NH_2 = 4.2 \times 10^{-4}$.

Do the appropriate calculations to sketch a titration curve for this titration.



Go Vikings!!

Formulas from the AP Exam:

EQUILIBRIUM

$$K_a = \frac{[H^+][A^-]}{[HA]}$$

$$K_b = \frac{[OH^-][HB^+]}{[B]}$$

$$K_w = [OH^-][H^+] = 1.0 \times 10^{-14} \text{ @ } 25^\circ C$$
$$= K_a \times K_b$$

$$pH = -\log [H^+], \ pOH = -\log [OH^-]$$
$$14 = pH + pOH$$

$$pH = pK_a + \log \frac{[A^-]}{[HA]}$$

$$pOH = pK_b + \log \frac{[HB^+]}{[B]}$$

$$pK_a = -\log K_a, \ pK_b = -\log K_b$$

$$K_p = K_c(RT)^{\Delta n},$$

where Δn = moles product gas − moles reactant gas

Calculations Practice

1) Weak, monoprotic
   → a strong acid would have buffer region from 5-20 mL

2) pH = 9 phenolphthalein

3) 25 mL

4) goes ½ way to equivalence point (12.5mL)

$pH = \boxed{4.8}$

$pKa = pH = \boxed{4.8}$

$Ka = 10^{-pKa} = 10^{-4.8} = \boxed{1.6 \times 10^{-5}}$

5) $HF \rightleftharpoons H^+ + F^-$

	HF	H^+	F^-
I	.050 M	0	0
C	$-x$	$+x$	$+x$
E	$.050 - \cancel{x}$	x	x

$Ka = \frac{[H^+][F^-]}{[HF]} = \frac{x^2}{.050} = 7.2 \times 10^{-4}$

$x = 0.0060$ too big to ignore

so $0.050 - 0.0060 = 0.044$

$\frac{x^2}{.044} = 7.2 \times 10^{-4}$

$x = 5.6 \times 10^{-3} = [H^+]$

$pH = \boxed{2.25}$

6) $HF + NaOH \rightarrow H_2O + NaF$

$HF + OH^- \rightarrow H_2O + F^-$

$V_1 M_1 = V_2 M_2$

$(10.0\,mL)(0.050\,M) = (x)(0.020\,M)$

$x = \boxed{25\,mL}$

7) $HF + OH^- \rightarrow H_2O + F^-$

8) moles F^- = moles HF

$(0.010\,L)\left(0.050\,\frac{mol}{L}\right) = \boxed{0.00050\,mol\ F^-}$

total volume $= 10.\,mL + 25\,mL = \boxed{0.035\,L}$

$[F^-] = \frac{(0.00050\,mol)}{(0.035\,L)} = \boxed{0.0143\,M\ F^-}$

9) $F^- + H_2O(l) \rightleftharpoons HF + OH^-$

	F^-	$H_2O(l)$	HF	OH^-
I	.0143		0	0
C	$-x$		$+x$	$+x$
E	$0.0143-\cancel{x}$		x	x

$K_b = \frac{K_w}{K_a} = \frac{1.0\times10^{-14}}{7.2\times10^{-4}} = 1.39\times10^{-11}$

$K_b = \frac{x^2}{.0143} = 1.39\times10^{-11}$ $x = [OH^-] = 4.46\times10^{-7}$

pH = $\boxed{7.65}$

10) pH = pKa Halfway to equivalence point

= 3.14

11) $(0.010\cancel{L})\left(.050\frac{mol}{\cancel{L}}\right) = .00050\, mol\ HF$

12) $(0.0050\cancel{L})\left(.020\frac{mol}{\cancel{L}}\right) = 1.0\times10^{-4}$

Total Volume = 15 mL = 0.015L

HF mixed w/ 5mL OH^-:

$$[HF] = \frac{0.00040\, mol}{.015\ L} = 0.0267\, M$$

$$[F^-] = \frac{0.00010\, mol}{.015L} = .00667\, M$$