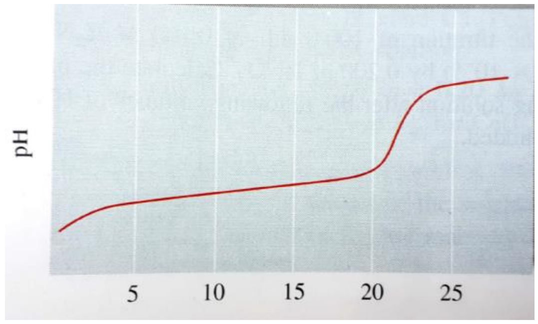
Acid-Base Titrations and Indicators Worksheet

1. Consider the titration of a weak acid, HA, with a strong base that gives the following pH curve.



On the curve, indicate the points that correspond to the following:

a. The stoichiometric (equivalence point)
b. The region with maximum buffering
c. pH = pKa
d. pH depends only on [HA]
e. pH depends only on $[A^-]$
f. pH depends only on the amount of excess strong base added

2. Consider the titration of 40.0 mL of 0.200 M $HClO_4$ with 0.100 M KOH. Calculate the pH of the resulting solution after the following volumes of KOH have been added:

a. 0.0 mL
b. 10.0 mL
c. 40.0 mL
d. 80.0 mL
e. 100.0 mL

3. Consider the titration of 80.0 mL of 0.100 M $Ba(OH)_2$ with 0.400 M HCl. Calculate the pH of the resulting solution after the following volumes of KOH have been added:

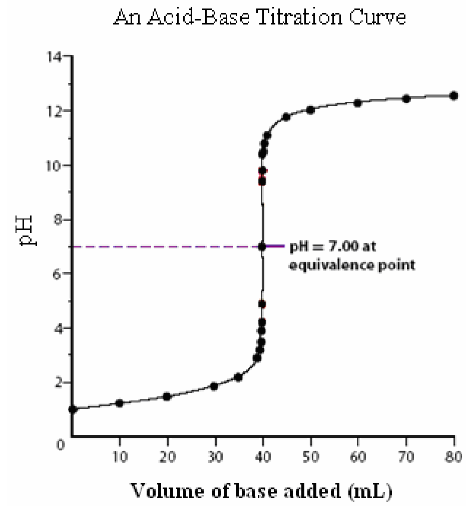
a. 0.0 mL
b. 20.0 mL
c. 30.0 mL
d. 40.0 mL
e. 80.0 mL

4. If 10.0 mL of 0.250 mol/L NaOH(aq) is added to 30.0 mL of 0.17 mol/L cyanic acid, HCNO(aq) (Ka = 3.5×10^{-4}), what is the pH of the resulting solution? (Hint: at the halfway point [HA]=[A-] therefore $[H^+] = K_a$ and pH = pK_a)

5. In the titration of 50.0 mL of 1.0 M methylamine, CH_3NH_2 ($K_b = 4.4 \times 10^{-4}$), with 0.50 M HCl, calculate the pH under the following conditions:

   a. After 50.0 mL of 0.50 M HCl has been added. (Hint: At halfway point [HA] = [A-] thus solution is a buffer. Use either regular stoichiometry-equilibrium step **OR** stoichiometric step then Henderson-Hasselbalch equation.)
   b. At the stoichiometric point. (Hint: the added H+ will convert all of the CH_3NH_2 into its conjugate acid, $CH_3NH_3^+$

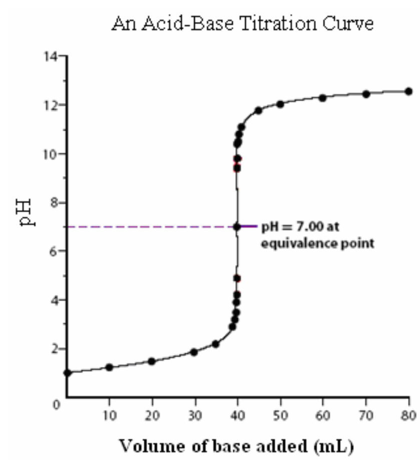
6. *Use the following information to answer the next question.*



Which of the following indicators is not appropriate for the above titration?

a. Phenol red
b. Methyl red
c. Alizarin yellow R
d. Bromothymol blue
e. All of the above are appropriate.

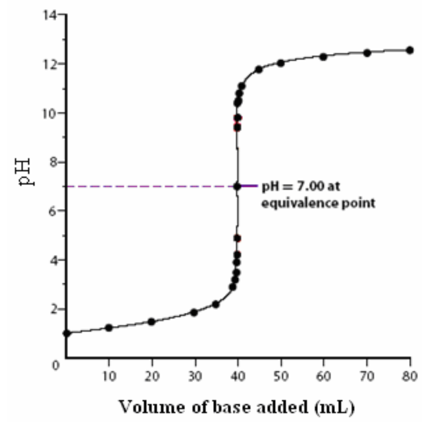
7. *Use the following information to answer the next question.*



Which of the following statements about the titration is FALSE?

a. The pH increases sharply near the equivalence point.
b. The solution formed at equivalence is neutral.
c. Phenolphthalein is a good indicator for this titration.
d. At equivalence, the addition of a small amount of acid or base has no effect on the pH of the solution.
e. All of the above statements are true.

8. Use the following titration curve to answer the next question.



The titration curve above could belong to which of the following acid-base pairs?

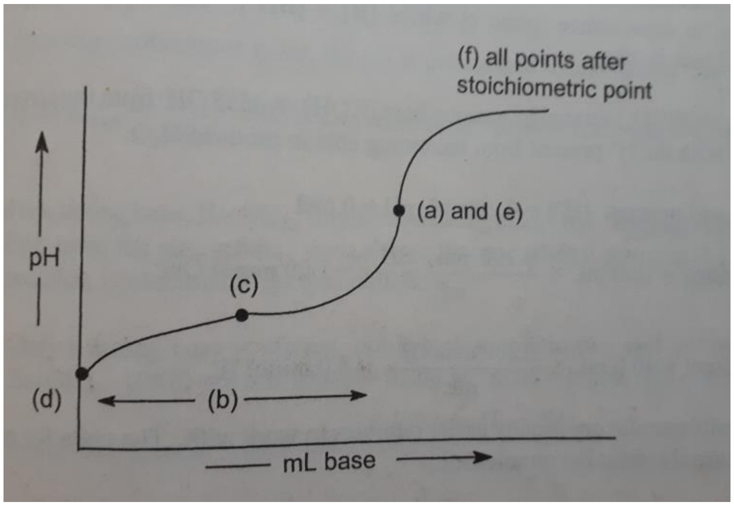
a. CH_3COOH (aq) and NaOH (aq)
b. HCl (aq) and NH_3(aq)
c. CH_3COOH (aq) and NH_3 (aq)
d. $HClO_4$ (aq) and KOH (aq)
e. CH_3CH_2COOH (aq) and KOH (aq)

9. Two drops of indicator HIn (Ka = 1.0 x 10-9), where HIn is yellow and In- is blue, are placed in 100.0 mL of 0.10 M HCl

   a. What colour is the solution initially?
   b. The solution is titrated with 0.10 M NaOH. At what pH will the colour change (yellow to greenish yellow) occur?
   c. What colour will the solution be after 200.o mL of NaOH has been added?

Answers:

1.



2. a. 0.699
   b. 0.854
   c. 1.301
   d. 7.00 (equivalence point)
   e. 12.15

3. a. 13.301
   b. 12.90
   c. 12.56
   d. 7.00 (equivalence point)
   e. 1.000

4. 3.46
5. a. 10.64
   b. 5.55

6. C
7. D
8. D
9. a. In a very acidic solution, the HIn form is expected to dominate, so the solution will be yellow
   b. The colour change occurs when the concentration of the dominant form is about ten times higher than the concentration of the less dominant.
   Thus,

$\frac{[HIn]}{[In-]} = \frac{10}{1}$; $K_a = 1.0 \times 10^{-9}$ M = $(\frac{10}{1})[H^+]$, $[H^+] = 1.0 \times 10\text{-}8$ M ; **At pH = 8.0 is when colour changes occurs.**