

Answers to Test-3 (Spring 2007)

✓ Please come to my office hours or talk to your classmates if you cannot get the right answers. If you find any grading error, please let me know.

I. Multiple choices:

1. (b)
2. (d)
3. (a)
4. (c)
5. (a)
6. (e); (e)
7. (b)
8. (a)
9. (b)
10. (a)
11. A; C
12. (b)
13. (c)
14. (b)

II. Problems:

1. See Example 12-7 in Lecture note of Chapter 12
2. See Example 12-5 in Lecture note of Chapter 12

III.

1. (see Lecture Note of Chapter 10-11: Slides 31-40)

(a) $V_{\text{NaOH}} = 0 \text{ mL}$

Since $\frac{K_{a1}}{K_{a2}} > 10^3$, treat as monoprotic acid
 $C_{\text{H}_2\text{A}}/K_{a1} > 100$,

$$[\text{H}_3\text{O}^+] = \sqrt{C_{\text{H}_2\text{A}} K_{a1}} = \sqrt{0.1000 \times 1.3 \times 10^{-4}} = 3.61 \times 10^{-3} \text{ M}$$

$$\text{pH} = -\log [\text{H}_3\text{O}^+] = -\log (3.61 \times 10^{-3}) = 2.44$$

(b) $V_{\text{NaOH}} = 10.00$; $0 < V_{\text{Titrant}} < V_{\text{1st equivalence point}}$ (The first buffer region)

$$\text{pH} = \text{p}K_{a1} + \log \frac{C_{\text{HA}^-}}{C_{\text{H}_2\text{A}}} = 3.89 + \log \frac{10.00 \times 0.1000}{(25.00 - 10.00) \times 0.1000} = 3.89 - 0.17 = 3.7$$

c) $V_{\text{NaOH}} = 25.00 \text{ mL} = V_{\text{1st equivalence point}}$

$$[\text{H}_3\text{O}^+] = \sqrt{\frac{K_{a2}C_{\text{HM}^-} + K_w}{1 + \frac{C_{\text{HM}^-}}{K_{a1}}}}$$

Since $\frac{C_{\text{HA}^-}}{K_{a1}} \gg 1$, $K_{a2}C_{\text{NaHA}} \gg K_w$, $K_{a2} < 10^{-3}$, $K_{b2} < 10^{-3}$

$$[\text{H}_3\text{O}^+] = \sqrt{K_{a1}K_{a2}} = \sqrt{1.3 \times 10^{-4} \times 5.9 \times 10^{-9}} = 8.76 \times 10^{-7} \text{ M}$$

$$\text{pH} = -\log [\text{H}_3\text{O}^+] = -\log (8.76 \times 10^{-7}) = 6.06$$

(d) $V_{\text{NaOH}} = 30.00$; $V_{\text{1st equivalence point}} < V_{\text{Titrant}} < V_{\text{2nd equivalence point}}$ (The second buffer region)

$$\text{pH} = \text{p}K_{a2} + \log \frac{C_{\text{A}^{2-}}}{C_{\text{HA}^-}} = 8.23 + \log \frac{5.00 \times 0.1000}{20.00 \times 0.1000} = 8.23 - 0.60 = 7.6$$

(e) $V_{\text{NaOH}} = 50.00 \text{ mL} = V_{\text{2nd equivalence point}}$

$$[\text{OH}^-] = \sqrt{C_b K_{b1}} = \sqrt{C_b \frac{K_w}{K_{a2}}} = \sqrt{0.03333 \times \frac{1.00 \times 10^{-14}}{5.9 \times 10^{-9}}} = \sqrt{5.65 \times 10^{-8}} = 2.38 \times 10^{-4} \text{ M}$$

$$\text{pH} = 10.38$$

(f) $V_{\text{NaOH}} = 55.00 \text{ mL} > V_{\text{2nd equivalence point}}$ (Beyond the 2nd equivalence point)

$$[\text{OH}^-] = \frac{\text{Moles of } [\text{OH}^-]_{\text{added}} - \text{Moles of } [\text{H}_3\text{O}^+]}{V_{\text{total}}}$$

$$= \frac{55.00 \times 0.1000 - 25.00 \times 0.1000 \times 2}{55.00 + 25.00} = 6.25 \times 10^{-3} \text{ M}$$

$$\text{pH} = 11.80$$

