**Additional practice questions on acid-base chemistry, from tests in 2005-2007.**

**ANSWERS**

1. How many of the following substances will form **basic solutions** when dissolved in water? KCN LiI IOH $NaClO_4$ $NaNO_2$ $K_2CO_3$

**(A)** 1

**(B)** 2

**(C)** 3

**(D)** 4

**(E)** 5

2. The titration of 10.00 mL of a weak base with 0.200 M hydrochloric acid solution reaches the half-equivalence point after adding 4.67 mL of acid. The pH at the half equivalence point is 9.57. Calculate the **initial concentration** and the $\mathbf{K_b}$ value **for the base**.

**(A)** 0.187 M $K_b = 3.7 \times 10^{-5}$

**(B)** 0.0934 M $K_b = 2.7 \times 10^{-10}$

**(C)** 0.200 M $K_b = 4.4$

**(D)** 0.187 M $K_b = 2.7 \times 10^{-10}$

**(E)** 0.200 M $K_b = 1.8 \times 10^{-5}$

3. Select the **TRUE** statements about the effects of dilution.

($K_a$ for HCOOH (formic acid) = $1.8 \times 10^{-4}$)

(i) Diluting 15 mL of a buffer that is 1.0 M each in HCOOH and HCOONa by adding 15 mL of $H_2O$ causes little or no change in the pH.

(ii) Diluting 15 mL of 1.0 M HCOOH by adding 15 mL of $H_2O$ would cause the pH to increase.

(iii) Diluting 15 mL of 1.0 M HCOOH by adding 15 mL of $H_2O$ would cause the percent ionization of HCOOH to decrease.

**(A)** i

**(B)** i, ii

**(C)** i, iii

**(D)** ii, iii

**(E)** i, ii, iii

4. Which of the following statements are **TRUE**?

(i) $I^-$ is a stronger base than $F^-$.

(ii) $NO_2^-$ is a stronger base than $NO_3^-$.

(iii) $H_2PO_3^-$ is the conjugate base of $HPO_3^{2-}$.

(iv) A 0.1 M solution of $H_2SO_4$ will have a higher pOH than a 0.1 M solution of $H_3PO_4$.

(v) The strongest base that will be present in water at equilibrium is $OH^-$.

**(A)** i, iii

**(B)** i, iii, v

**(C)** ii, iv, v

**(D)** ii, v

**(E)** iii, iv

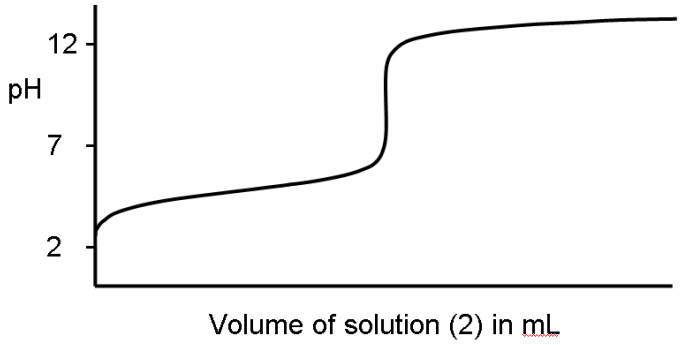
5. A 1.00 L solution with pH = 3.70 has 0.810 M $NaNO_2$(aq) and a certain concentration of $HNO_2$(aq). How many **moles of HCl(g)** must be added to change the pH of the solution by 0.24 pH units? Assume no volume change on the addition of HCl(g). ($K_a$ for $HNO_2$ = $7.1 \times 10^{-4}$)

**(A)** 0.11 mol
**(B)** 0.17 mol
**(C)** 0.27 mol
**(D)** 0.34 mol
**(E)** 0.40 mol

6. What is the **$[H_3O^+]$** in a 175 mL sample of 0.0629 M KOH(aq)?

**(A)** $9.08 \times 10^{-13}$ mol $L^{-1}$
**(B)** $6.08 \times 10^{-13}$ mol $L^{-1}$
**(C)** **$1.59 \times 10^{-13}$ mol $L^{-1}$**
**(D)** $8.17 \times 10^{-14}$ mol $L^{-1}$
**(E)** $2.78 \times 10^{-14}$ mol $L^{-1}$

7. The graph below is the titration curve resulting from the addition of a 0.2 M solution of (2) to a 0.2 M solution of (1). **Identify the two species (1) and (2).**




| | | | | |
|---|---|---|---|---|
| **(A)** | (1) | a strong acid | (2) | a strong base |
| **(B)** | **(1)** | **a weak acid** | **(2)** | **a strong base** |
| **(C)** | (1) | a strong acid | (2) | a weak base |
| **(D)** | (1) | a weak acid | (2) | a weak base |
| **(E)** | (1) | pure water | (2) | a strong base |

8. Shikimic acid, a naturally occurring monoprotic acid, is the starting material for the synthesis of Tamiflu, the anti-viral drug being stockpiled in preparation for an avian flu pandemic. A 0.28 M solution of shikimic acid (20.0 mL) was treated with sufficient 0.15 M KOH solution to reach the equivalence point. The pH of the resulting solution was 8.73. **Calculate the $pK_a$** of shikimic acid.

**(A)** **4.47**
**(B)** 5.27
**(C)** 7.00
**(D)** 8.73
**(E)** 9.53

9. A certain mass of chloroacetic acid ($ClCH_2COOH$, $K_a = 1.4 \times 10^{-3}$) is dissolved in sufficient water to produce 1.50 L of a solution with pH = 1.63. **What mass (in g) of $ClCH_2COOH$** is required to produce this solution?

**(A)** 0.62 g
**(B)** 14 g
**(C)** 27 g
**(D)** 39 g
**(E)** **59 g**

10. **Which of the following indicators** would be best suited to indicate the equivalence point of the titration of 50.0 mL of 0.15 M triethylamine, $N(CH_2CH_3)_3$, ($K_b = 5.2 \times 10^{-4}$) with 0.25 M $HNO_3$?

| | Indicator | Colour Change Range |
|---|---|---|
| **(A)** | bromphenol blue | 3.2 – 4.8 |
| **(B)** | **bromocresol purple** | **5.2 – 6.7** |
| **(C)** | phenol red | 6.8 – 8.3 |
| **(D)** | *o*-cresolphthalein | 8.3 – 9.7 |
| **(E)** | alizarin yellow | 10 - 12 |

11. Two Chemistry 1AA3 students were doing a titration experiment. Student 1 placed 50.0 mL of 0.180 M propanoic acid ($K_a$ = 1.3 ×$10^{-5}$) into an Erlenmeyer flask and Student 2 titrated the acid to the equivalence point with 0.290 M NaOH. When it was time to repeat the titration, student 1 poured the second 50.00 mL aliquot of 0.180 M propanoic acid into the previously titrated solution by mistake. Calculate **the pH of the solution after the second 50.00 mL of propanoic acid had been added**.

**(A)** 2.9
**(B)** **4.9**
**(C)** 7.0
**(D)** 9.0
**(E)** 9.1

12. Find the **pH of the solution that results** when the following solutions are mixed together: ($K_a$ $CH_3COOH$ = 1.8 × $10^{-5}$)

100. mL of 0.100 M NaOH(aq)
50.0 mL of 0.200 M HCl(aq)
62.5 mL of 0.160 M $CH_3COOH$(aq)

**(A)** 1.33
**(B)** 2.77
**(C)** **3.04**
**(D)** 3.96
**(E)** 4.74

13. Which of the following combinations of aqueous solutions **will result in the formation of a buffer solution**? (All stock aqueous solutions are 0.100 M).

**(A)** 50 mL $HClO_3$ + 25 mL $NaClO_3$
**(B)** 50 mL $HClO_2$ + 50 mL KOH
**(C)** 25 mL $HClO_2$ + 50 mL NaOH
**(D)** 50 mL $HClO_3$ + 50 mL $NaClO_2$
**(E)** **50 mL $HClO_2$ + 25 mL NaOH**

14. A student prepares 1.50 L of a solution that contains 0.862 mol of sodium benzoate ($C_6H_5COONa$) and sufficient moles of benzoic acid ($C_6H_5COOH$, $K_a = 6.3 \times 10^{-5}$) to give pH = 4.86. The student wishes to adjust the solution pH to be 5.12. How many **moles of NaOH(s)** must the student add? (Assume no volume change on addition of NaOH(s)).

**(A)** **0.076 mol**
**(B)** 0.085 mol
**(C)** 0.11 mol
**(D)** 0.19 mol
**(E)** 0.27 mol

15. 10.00 mL of 0.101 M acetic acid was diluted with distilled water to 40.00 mL and titrated with 0.100 M NaOH. **Calculate the $H_3O^+$ concentration at the equivalence point. (**$K_a$ $CH_3COOH$ = $1.8 \times 10^{-5}$).

**(A)** $4.22 \times 10^{-9}$ M

**(B)** $3.27 \times 10^{-9}$ M

**(C)** **$2.99 \times 10^{-9}$ M**

**(D)** $2.36 \times 10^{-6}$ M

**(E)** $3.35 \times 10^{-6}$ M

16. Which of the following statement(s) about weak acids and weak bases is/are **FALSE**?

i. Weak acids can never dissociate fully in water.

ii. Weak bases react with water to produce a small amount of a strong base.

iii. Indicators are weak acids (or weak bases) with a colour change range that encompasses the $pK_a$ (or the $pK_b$) of the indicator.

iv. The conjugate partner of a weak acid will react completely with a strong acid.

**(A)** i

**(B)** ii

**(C)** iii

**(D)** iv

**(E)** i and iv

17. A 0.270 M solution of HF (40.0 mL) was titrated with a 0.410 M KOH solution. **What is the pH** of the solution after 28.0 mL of the KOH solution have been added to the HF solution? [$K_a$ (HF) = 4.5 x $10^{-4}$]

**(A)** 11.6
**(B)** 7.00
**(C)** 12.2
**(D)** 3.35
**(E)** 12.0

18. **Indicate the factor(s)** that govern the selection of an indicator for a neutralization titration.

(i) the final volume of the solution
(ii) the volume of titrant
(iii) the molarity of the standard solution
(iv) the pH at the stoichiometric (equivalence) point
(v) the $pK_a$ of the indicator

**(A)** i and v
**(B)** ii and iii
**(C)** ii, iii and iv
**(D)** iv and v
**(E)** v

19. Assuming no volume change on mixing, **what mass of solid ammonium chloride** should be added to 250.0 mL of 0.25 M ammonia to produce a solution of pH 10.70? [$K_b$ ($NH_3$) = 1.8 x $10^{-5}$]

**(A)** 120 mg
**(B)** 3010 mg
**(C)** 402 mg
**(D)** 56.2 mg
**(E)** 1204 mg

20. A solution was prepared by dissolving 0.10 mol of benzoic acid [$K_a$ = 6.3 x $10^{-5}$] and 0.50 mol of sodium benzoate in sufficient pure water to form a 1.00 L solution. To a 70.0 mL aliquot of this solution was added 2.00 mL of 2.00 M HI. **What is the pH** of the resulting solution?

**(A)** 2.84
**(B)** 3.16
**(C)** 3.36
**(D)** 4.65
**(E)** 4.88