## Acid Base Equilibrium Study Guide – Multiple Choice

D 1. The pH of 0.1 molar sodium hydroxide is

a. 1 $[OH^-] = 0.1\ M = 1 \times 10^{-1}$ c. 11 $pH = 14 - 1 = 13$

b. 4 $pOH = -\log(1 \times 10^{-1}) = 1$ d. 13

B 2. In titrating 0.20 M hydrochloric acid, HCl, with 0.20 M NaOH at 25°C, the solution at the equivalence point is $HCl + NaOH \rightarrow H_2O + NaCl$

a. 0.20 M NaCl

b. 0.10 M NaCl

c. slightly acidic pH = 7

d. 0.10 M HCl and 0.20 M NaOH

mols HCl = mols NaOH = mols NaCl

Equal volumes of HCl + NaOH will be used since they have same molarity. Thus the total volume is double the volume of HCl used.

$\therefore [NaCl] = \frac{x\ mol}{\text{Twice volume}} = \frac{.2M}{2} = .1\ M$

3. Consider the following indicators and their pH ranges:

| | |
|---|---|
| Methyl orange | 3.2-4.4 |
| Methyl red | 4.8-6.0 |
| Bromothymol blue | 6.0-7.6 |
| Phenolphthalein | 8.2-10.0 |
| Alizarin yellow | 10.1-12.0 |

Acidic pH at equivalence point

Assume an indicator works best when the equivalence point of a titration comes in the middle of the indicator range. For which of the following titrations would methyl red be the best indicator?

a. 0.100 M $HNO_3$ + 0.100 M KOH pH = 7

C b. 0.100 M amiline ($K_b = 3.8 \times 10^{-10}$) + 0.100 M HCl pH << 7 weaker base than $NH_3$ ∴ pH at equiv. will be more acidic << 7

c. 0.100 M $NH_3$ ($K_b = 1.8 \times 10^{-5}$) + 0.100 M HCl pH < 7

d. 0.100 M HF ($K_a = 7.2 \times 10^{-4}$) + 0.100 M NaOH pH > 7

4. A 0.20-molar solution of a weak monoprotic acid, HA, has a pH of 3.00. The ionization constant of this acid is

a. $5.0 \times 10^{-7}$

C b. $2.0 \times 10^{-7}$

c. $5.0 \times 10^{-6}$

d. $2.0 \times 10^{-3}$

$pH = 3 \quad \therefore [H^+] = 10^{-3}\ M = X$

$K_a = \frac{X^2}{[HA]_{initial}} = \frac{(10^{-3})^2}{0.2} = \frac{10^{-6}}{0.2}$

$= \frac{1}{.2} \times 10^{-6}$

$= 5 \times 10^{-6}$

C

5. In the titration of a weak acid of unknown concentration with a standard solution of a strong base, a pH meter was used to follow the progress of the titration. Which of the following is true for this experiment?

   a. The $[H^+]$ at the equivalence point equals the ionization constant of the acid.
   b. The pH at the equivalence point depends on the indicator used.
   c. The graph of the pH versus volume of base added rises gradually at first then much more rapidly.
   d. The graph of pH versus volume of base added shows no sharp rise.

B

OMIT

Not on Test

6. Equal volumes of 0.10-molar $H_3PO_4$ and 0.20-molar KOH are mixed. After equilibrium is established, the type of ion in solution in the largest concentration, other than $K^+$ ion is,

   a. $H_2PO_4^-$
   b. $HPO_4^{2-}$
   c. $PO_4^{3-}$
   d. $OH^-$

$H_3PO_4 \rightleftharpoons H^+ + H_2PO_4^-$

$H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{2-}$

$HPO_4^{2-} \rightleftharpoons H^+ + PO_4^{3-}$

↖ Excess $OH^-$ reacts w/ $H^+$ causing reverse shift & more $HPO_4^{2-}$ made

B

7. The pH of a solution prepared by the addition of 10. mL of 0.002 M KOH(aq) to 10. mL of distilled water is closest to

   a. 12
   b. 11
   c. 10
   d. 4

Volume doubles ∴ $[OH^-]$ Halved $= \frac{0.002}{2} = 0.001$

$[OH^-] = 1 \times 10^{-3}$ M

$pOH = -\log(1 \times 10^{-3}) = 3$ $\quad pH = 14 - 3 = 11$

B

8. Which of the following mixtures would make a buffer?

   a. HCl + NaCl strong acid + CB
   b. HF + NaF weak acid + CB
   c. HBr + NaBr strong acid + CB
   d. HI + NaI strong acid + CB

Weak Acid + Conjugate Base

weak acid = ICE ⇒ $X = [H^+]$

9. What is the $H^+$ concentration in 0.05 M HCN? (Ka for HCN is $5.0 \times 10^{-10}$)

C
a. $2.5 \times 10^{-10}$
b. $5.0 \times 10^{-10}$
c. $5.0 \times 10^{-6}$
d. $5.0 \times 10^{-4}$

$K_a = \frac{x^2}{[HCN]}$

$5 \times 10^{-10} = \frac{x^2}{0.05}$

$x^2 = (5 \times 10^{-10})(5 \times 10^{-2})$

$x^2 = 25 \times 10^{-12}$

$x = 5 \times 10^{-6} = [H^+]$

10. A 1-molar solution of which of the following salts has the highest pH?

Most Basic

B
a. $Na_2SO_4$ (N, N)
b. $Na_2CO_3$ (N, B)
c. $NH_4Cl$ (A, N)
d. $NaHSO_4$ (N, N)

ions of strong = neutral

weak: positive ions = acidic; negative ions = basic

$HC_2H_3O_2(aq) + CN^-(aq) \leftrightarrow HCN(aq) + C_2H_3O_2^-(aq)$

11. The reaction represented above has an equilibrium constant equal to $3.7 \times 10^{-4}$. Which of the following can be concluded from this information?

$K_{eq}$

$K_{eq} < 1$ Reactant favored

B
a. $CN^-(aq)$ is a stronger base than $C_2H_3O_2^-(aq)$.
b. $HCN(aq)$ is a stronger acid than $HC_2H_3O_2(aq)$. (Reactant favored means HCN is more likely than $HC_2H_3O_2$ to donate $H^+$)
c. The conjugate base of $CN^-(aq)$ is $C_2H_3O_2^-(aq)$.
d. The pH of a solution containing equimolar amounts of $CN^-(aq)$ and $HC_2H_3O_2(aq)$ is 7.0.

Heat + $H_2O(l) + H_2O(l) \leftrightarrow H_3O^+(aq) + OH^-(aq)$

12. The autoionization of water, as represented by the equation above, is known to be endothermic. Which of the following correctly describes what occurs as the temperature of water is raised? ⇒ shift forward = more $H_3O^+$ = lower pH

B
a. $[H_3O^+]$ increases, causing pH to increase.
b. $[H_3O^+]$ increases, causing pH to decrease.
c. $[H_3O^+]$ decreases, causing pH to increase.
d. $[H_3O^+]$ decreases, causing pH to decrease.

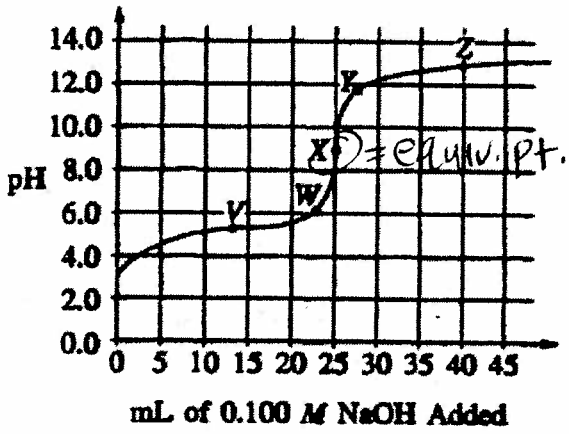
| Chemical Formula | Dissociation Constant |
|---|---|
| $CH_3COOH$ acid | $K = 1.8 \times 10^{-5}$ = $K_a$ |
| $NH_3$ base | $K = 1.8 \times 10^{-5}$ = $K_b$ |
| $H_2CO_3$ acid | $K_1 = 4 \times 10^{-7}$ = $K_a$ |
| $HCO_3^-$ acid | $K_2 = 4 \times 10^{-11}$ = $K_a$ |

13. A buffer solution is prepared by mixing equal volumes of 0.50 M weak acid with 1.0 M of its conjugate base. Based on the data given in the table above, which of the following should be used to prepare the buffer solution with a pH between 4 and 7?

B

a. $CH_3COOH$ and $NH_3$ Not a buffer
b. $CH_3COOH$ and $CH_3COONa$ Buffer ← The only combo that is a buffer!
c. $H_2CO_3$ and $NH_3$ Not a buffer
d. $H_2CO_3$ and $Na_2CO_3$ Not a buffer

Questions 14-15: The graph to the right shows the titration curve that results when 100. mL of 0.0250 M acetic acid is titrated with 0.100 M NaOH.




14. Which of the following indicators is the best choice for this titration?

D

| Indicator | pH Range of Color Change |
|---|---|
| a. Methyl orange | 3.2 – 4.4 |
| b. Methyl red | 4.8 – 6.0 |
| c. Bromothymol blue | 6.1 – 7.6 |
| d. Phenolphthalein | 8.2 – 10.0 |

15. What part of the curve corresponds to the optimum buffer action for the acidic/acetate ion pair? perfect buffer = Half Equiv. pt.

A

a. Point V
b. Point Z
c. Along all of section WY
d. Along all of section YZ