Chemistry 12

Acid Base Part 2 Review Package

Name: Key
Date:
Block:

I. Multiple Choice

1. Consider the following data:

Solution	Initial pH	Final pH
1	1.0	4.0
2	2.0	6.0
3	6.0	3.0
4	9.0	3.0

pH $6.0 \rightarrow 5.0 \rightarrow 4.0 \rightarrow 3.0$
×10
×100
×1000

In which solution has the $[H_3O^+]$ increased 1000 times?

A. 1
B. 2
C. 3
D. 4

2. A solution is amber with neutral red and colourless with phenolphthalein. The approximate pH of the solution is:

A. 4
B. 6
C. 8
D. 10

3. Consider the following equilibrium for an acetic acid buffer solution:

$$CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$$

When a small amount of acid is added to this system, and equilibrium is reestablished,

A. $[CH_3COO^-]$ and pH have both increased
B. $[CH_3COOH]$ and pH have both decreased
C. $[CH_3COO^-]$ has decreased and pH remains relatively constant
D. $[CH_3COOH]$ has decreased and pH remains relatively constant.

4. The stoichiometric point of a titration is reached when 35.50 mL 0.40 M HBr is added to a 25.00 mL sample of LiOH. The original [LiOH] is:

$$0.03550\,L_{HBr} \times \frac{0.40\,mol\,HBr}{1\,L\,HBr} \times \frac{1\,mol\,LiOH}{1\,mol\,HBr} \times \frac{1}{0.02550\,L} = \boxed{0.56\,M_{LiOH}}$$

A. 0.014 M
B. 0.024 M
C. 0.28 M
D. 0.57 M

5. A buffer solution can be prepared by mixing equal numbers of moles of:

Weak acid & Conjugate base

A. NH_4Cl and ~~HCl~~ SA
B. NaCl and ~~NaOH~~ SB
C. Na_2CO_3 ✓ and $NaHCO_3$ ✓
D. $NaCH_3COO$ and ~~NaOH~~ SB
not conjugates!

6. Which of the following, when dissolved in water, produces a **basic** solution?

spec

A. ~~KCl~~

B. ~~NaClO~~$_4$

spec

spec

C. ~~Na~~$_2$CO$_3$ WB

D. NH$_4$~~NO~~$_3$

WA spec

no spec

7. The net ionic equation for the hydrolysis of ~~Na~~$_2$CO$_3$ is:

spec

~~A.~~ $H_2O + Na^+ \leftrightharpoons NaOH + H^+$

~~B.~~ $H_2O + 2Na^+ \leftrightharpoons Na_2O + 2H^+$

C. $H_2O + CO_3^{2-} \leftrightharpoons H_2CO_3 + O^{2-}$

D. $H_2O + CO_3^{2-} \leftrightharpoons HCO_3^- + OH^-$

8. When 1.0 M NH$_3$ is titrated with 1.0 M HCl, the most suitable indicator is:

A. methyl violet.

B. indigo carmine.

C. phenolphthalein.

D. bromcresol green.

	HCl	$+ NH_3$	$\rightleftharpoons NH_4^+$	$+ Cl^-$
I	0.5	0.5	0	
C	-0.5	-0.5	+0.5	
E	0	0	0.5 WA	

	NH_4^+	$+ H_2O$	$\rightleftharpoons NH_3$	$+ H_3O^+$
I	0.5		0	0
C	$-x$		$+x$	$+x$
E	$0.5-x$		x	x

assume $0.5-x \approx 0.5$

$5.6\times10^{-10} = \frac{x^2}{0.5}$

$x = 1.7\times10^{-5} = [H_3O^+]$

$pH = 4.78$

9. All buffer solutions are able to

A. maintain pH at 7.00.

B. neutralize acidic solutions only.

C. maintain a relatively constant pH.

10. The most appropriate indicator for the titration of 0.50 M CH$_3$COOH with 0.50 M NaOH is (ICE table calculation necessary!)

(see #8 for how to calculate)

A. methyl red.

B. indigo carmine.

C. phenolphthalein.

D. bromcresol green.

11. An indicator is useful for a titration when its K$_a$ is close to

A. K_w / K_b

B. the pH at the equivalence point.

C. the [H$^+$] at the equivalence point.

D. the concentration of the acid form of the indicator.

$K_a = \frac{\cancel{[Ind^-]}[H_3O^+]}{\cancel{[HInd]}}$

12. In order to change the pH of a solution from 2.0 to 4.0 to the [H$_3$O$^+$] must:

A. decrease by a factor of 100

B. decrease by a factor of 2

C. increase by a factor of 2

D. increase by a factor of 100

more basic

13. Which of the following represents the predominant reaction between HCO$_3^-$ and water?

A. $2HCO_3^- + H_2O \leftrightharpoons H_3O^+ + CO_3^{2-} + OH^- + CO_2$

B. $HCO_3^- + H_2O \leftrightharpoons H_3O^+ + CO_3^{2-}$

C. $HCO_3^- + H_2O \leftrightharpoons H_2CO_3 + OH^-$

D. $2HCO_3- \leftrightharpoons H_2O + 2CO_2$

$K_a = 5.6\times10^{-11}$

$K_b = \frac{K_w}{4.7\times10^{-7}} = 2.1\times10^{-8}$

14. Which of the following applies at the transition point for all indicators, HInd?
   A. [HInd] = [Ind^-]
   B. [H_3O^+] = [OH^-]
   C. [Ind^-] = [H_3O^+]
   D. [HInd] = [H_3O^+]

$$K_a = \frac{[Ind^-][H_3O^+]}{[HInd^-]}$$

15. Which of the following 1.0M solutions would have a pH greater than 7.00? basic
   A. HCN WA
   B. ~~NH_4Cl~~ WA
   C. ~~KNO_3~~
   D. $NaCH_3COO$ WB

16. What is the pH of the solution formed when 0.040 mol $NaOH_{(s)}$ is added to 2.00 L of 0.020M HCl?
   A. 7.00
   B. 1.70
   C. 1.40
   D. 0.00

SB $[NaOH] = \frac{0.040 mol}{2.00 L} = 0.020M$

SA $[HCl] = 0.020M$ equal!

17. A buffer solution may contain equal moles of
   A. strong acid and its conjugate base.
   B. weak acid and strong base.
   C. weak acid and its conjugate base.
   D. strong acid and strong base.

I. **Problems**

1. Determine the pH of a 0.75M solution of $Sr(HSO_3)_2$.

$$Sr(HSO_3)_2 \rightarrow \cancel{Sr^{2+}} + 2HSO_3^-$$

0.75M   ~~0.75M~~ spec   1.50M

$K_a = 1.0\times10^{-7}$

$K_b = \frac{1.00\times10^{-14}}{1.5\times10^{-2}} = 6.7\times10^{-13}$

$$HSO_3^- + H_2O \rightleftharpoons SO_3^{2-} + H_3O^+$$

	HSO_3^-	H_2O	SO_3^{2-}	H_3O^+
I	1.50M		0	0
C	$-x$		$+x$	$+x$
E	$1.50-x$		x	x

↳ assume $1.50-x \cong 1.50$

$$1.0\times10^{-7} = \frac{x^2}{1.50}$$

$$x = \sqrt{(1.0\times10^{-7})(1.50)}$$

$$= 3.9\times10^{-4}M = [H_3O^+]$$

$$\boxed{pH = 3.41}$$

2. Consider the salt sodium oxalate ($Na_2C_2O_4$). When a few drops 1.0M solution of sodium oxalate is added to phenolphthalein indicator the solution turns pink. Write a hydrolysis equation and an equilibrium expression to explain the shift that caused the indicator to change colour.

$$Na_2C_2O_4 \rightarrow \cancel{2Na^+} + \underbrace{C_2O_4^{2-}}_{\text{WB hydrolysis}}$$

spec

$$C_2O_4^{2-} + H_2O \rightleftharpoons HC_2O_4^- + OH^-$$

Phenolphthalein

$$\underset{\substack{\text{(acidic)}\\\text{colourless}}}{HIn} + H_2O \rightleftharpoons \underset{\substack{\text{(basic)}\\\text{pink}}}{In^-} + H_3O^+$$

Adding OH^- results in the equilibrium to shift right, causing $[In^-]\uparrow$ and expressing the pink colour

3. a) Calculate the pH of the solution produced when 9.00 mL of 0.200 M NaOH has been added to 20.0 mL of 0.200 M HCOOH.

TB

WA

[HCOOH]

$$(0.200)(20.0) = C_2(29.0)$$
$$C_2 = 0.138M$$

[NaOH]

$$(0.200)(9.00) = C_2(29.0)$$
$$C_2 = 0.0621M$$

	$HCOOH$ +	$NaOH$ $\longrightarrow$	$NaCOOH$ +	H_2O
I	0.138	0.0621	0	
C	-0.0621	-0.0621	+0.0621	
E	0.0759	0	0.0621	

acid buffer

$$[H_3O^+] = Ka\left(\frac{[acid]}{[base]}\right)$$
$$= 1.8\times10^{-4}\left(\frac{0.0759}{0.0621}\right) = 2.2\times10^{-4}$$

$$\boxed{pH = 3.67}$$

b) How many mL of NaOH have been added at equivalence point?

$$0.0200\,L_{HCOOH} \times \frac{0.200\,mol\,HCOOH}{1\,L} \times \frac{1\,mol\,NaOH}{1\,mol\,HCOOH} \times \frac{1\,L_{NaOH}}{0.200\,mol}$$

$$= 0.0200\,L_{NaOH} = \boxed{20.0\,mL_{NaOH}}$$

c) Calculate the pH at the equivalence point of this titration.

[HCOOH]

$$(0.200)(20.0) = C_2(40.0)$$
$$C_2 = 0.100M$$

[NaOH]

$$(0.200)(20.0) = C_2(40.0)$$
$$C_2 = 0.100M$$

spec

	$HCOOH$ +	$NaOH$ $\longrightarrow$	$\cancel{N}aCOOH$ +	H_2O
I	0.100	0.100	0	
C	-0.100	-0.100	+0.100	
E	0	0	0.100	

WB hydrolysis

	$COOH^-$	$+$	H_2O	$\rightleftharpoons$	$HCOOH$	$+$	OH^-
I	0.100				0		0
C	$-x$				$+x$		$+x$
E	$0.100-x$				x		x

↳ assume $\cong 0.100$

$$K_b = \frac{K_w}{1.8\times10^{-4}} = 5.6\times10^{-11} = \frac{x^2}{0.100}$$

$$x = \sqrt{(5.6\times10^{-11})(0.100)}$$

$$= 2.4\times10^{-6} = [OH^-]$$

$$pOH = 5.63$$

$$\boxed{pH = 8.37}$$