# CHM 152 Exam II, Burk Fall 2009

**Name** KEY **Date** **Score**

**Multiple Choice: Circle the BEST answer!**
**(2 points each)**

1) Which of the following is the definition of a Lewis Acid?
   a. Proton Donor
   b. Contains Hydrogen
   c. Electron Acceptor
   d. None of the above
2) Which of the following is the conjugate base to $NH_4^+$?
   a. $NH_3$
   b. $NH_2^-$
   c. $NH_5$
   d. None of the above
3) Which of the following is the conjugate acid to $Ba(OH)_2$ ?
   a. Ba
   b. $OH^-$
   c. $Ba^{2+}$
   d. None of the above
4) Water is an amphoteric substance, meaning …
   a. It can acts as an acid or base
   b. Is neutral
   c. Can be consumed
   d. None of the above
5) Which of the following is the Bronsted-Lowry definition of a base?
   a. Proton donor
   b. Proton acceptor
   c. Electron donor
   d. Electron acceptor
   e. None of the above
6) What is the pH at the equivalence in a titration between a weak base and strong acid?
   a. Equal to 7
   b. Less than 7
   c. Greater than 7
   d. None of the above
7) Identify $Ba(ClO_3)_2$ as which of the following?
   a. Acid
   b. Base
   c. Basic salt
   d. Acidic salt
   e. Neutral salt
   f. None of the above

8) Which of the following pairs of substances will make a good buffer solution?
   a. NaCl and HCl
   b. HOCl and KOCl
   c. KOH and HBr
   d. HCN and HCl
   e. $NH_3$ and $H_2O$
9) Which of the following is TRUE, if calcium sulfate ($CaSO_4$) is added to a solution containing 2.0 M $H_2SO_{4(aq)}$?
   a. The solubility of $CaSO_4$does not change
   b. The solubility of $CaSO_4$ will increase
   c. The solubility of $CaSO_4$ will decrease
   d. None of the above
10) Which of the following salts will change the pH of a solution? Circle **ALL** that apply!!!
   a. NaCl
   b. $K_2CO_3$
   c. $NaNO_2$
   d. LiBr
   e. $KClO_4$
11) pH effects the solubility of metal hydroxides.
   a. True
   b. False
12) A strong acid would have a percent dissociation …
   a. Near 100%
   b. Less than 100%
   c. Near 0%
   d. Not enough information
13) Which of the following is FALSE for polyprotic acids?
   a. They are all strong acids
   b. They have more than one proton to donate
   c. The first protons is easier to remove than the subsequent protons
   d. None of the above
14) Ammonia reacts with water.
   a. True
   b. False
15) Small highly charged metals can be…
   a. Acidic salts
   b. Basic salts
   c. Neutral salts
   d. None of the above
16) By the addition of a common ion which of the following can change?
   a. The pH
   b. Solubility
   c. A shift in the reaction
   d. All of the above

17) The pH of a buffer's range is within _____ of the $pK_a$.
   a. 1 unit
   b. 2 units
   c. 3 units
   d. None of the above

18) It may take several chemical reaction steps to create a complex ion.
   a. True
   b. False

19) The reaction quotient, $Q_{sp}$, needs to be _____ $K_{sp}$ for a precipitant to form.
   a. Equal to
   b. Greater than
   c. Less than
   d. None of the above

20) Which of the following will NOT affect solubility?
   a. Temperature
   b. The formation of a complex ion
   c. pH
   d. None of the above

**Short Answer/Multiple Choice: <u>You MUST Show Work to get Credit</u>!!!**

21) (1 pt) Circle the **conjugate base** in the equation below:

$$C_6H_5COOH_{(l)} + H_2O_{(l)} \rightleftharpoons C_6H_5COO^-_{(aq)} + H_3O^+_{(aq)}$$

22) (1 pt) Write the formula for the **conjugate acid** of $SO_4^{-2}{}_{(aq)}$. $HSO_4^-$ (- ½ for $H_2SO_4$)

23) (8 pts) Calculate $[H_3O^+]$, $[OH^-]$, pH, and pOH when 0.0915 moles of nitric acid is placed in 250.0 mL of water.

$$\frac{0.0915\ mol}{0.2500L} = 0.0760\ M\ HNO_3 => 0.366\ M\ H_3O^+\ (strong\ acid)$$

$$pH = -\log(0.366) = 0.437$$

$$pOH = 14 - 0.437 = 13.563$$

$$[OH^-] = 10^{-pOH} = 10^{-13.563} = 2.74 \times 10^{-14} M$$

Or could use $K_w = [H_3O^+][OH^-]$

$$1.0 \times 10^{-14} = (0.366)[OH^-]$$

$$[OH^-] = 2.7 \times 10^{-14}$$

$$pOH = -\log(2.7 \times 10^{-14}) = 13.57$$

(2 pts) (2 pts) (2 pts) (2 pts)

$[H_3O^+]$ = **$0.366\ M$**, $[OH^-]$ = **$2.74 \times 10^{-14} M$** or **$2.7 \times 10^{-14}$**, pH = **$0.437$**, pOH = **$13.563$** or **$13.57$**

24) (6 pts – ½ pt each) Label the following chemicals as strong acid (**SA**), strong base (**SB**), weak acid (**WA**), weak base (**WB**), acidic salt (**AS**), basic salt (**BS**), or neutral salt (**NS**).

a. $Ca(OH)_2$ __SB___ e. HF ____WA___ i. $NH_3$ ____WB_____

b. HI __SA__ f. $Na_2CO_3$ ___BS___ j. LiF ____BS_____

c. $NH_4Br$ ___AS____ g. $K_3PO_4$ ____BS___ k. $Ba(Cl)_2$ __NS____

d. $KNO_3$ ___NS___ h. $KCH_3COO$ __BS__ l. LiOH _____SB__

25) (7 pts) a) Calculate all equilibrium concentrations of a 0.250 M hydrazoic acid ($HN_3$) solution? $K_a$ = 1.9 x $10^{-5}$ (**Write the reaction for this acid in water for full credit**)

$HN_3 + H_2O \leftrightarrow H_3O^+ + N_3^-$ $\quad K_a = \frac{[H_3O^+][N_3^-]}{[NH_3]}$

(3 pts) 0.250 | 0 | 0

-x | +x | +x

0.250-x | x | x

(0.250-0.0022) = 0.248

$1.9 \times 10^{-5} = \frac{(x)(x)}{(0.250-x)}$ → 0

$\sqrt{4.8 \times 10^{-6}} = \sqrt{x^2}$

$x = 0.0022M$ ( 1 pt)

$[HN_3]_{eq}$ = __0.248 M__ (1 pt)

$[H_3O^+]_{eq}$ = __0.0022 M__ (1 pt)

$[N_3^-]_{eq}$ = __0.0022 M (1 pt)

a. (1 pt) What is the pH of the solution? pH = -log(0.0022) **= 2.66**

b. (1 pt) What is the percent dissociation of this acid solution?

% ionization = $\frac{[H_3O^+]_{eq}}{[HA]_i} \times 100 = \frac{0.0022}{0.250} \times 100 =$ **0.88%**

26) (8 pts) Calculate the pH of a solution made by adding 0.3564 grams of solid lithium cyanide (LiCN) to 0.9981 L of water. $K_a$ for hydrocyanic acid (HCN) is 4.90 x $10^{-10}$. **Show all relevant equations, expressions, calculations and circle the answer for full credit**

$0.3564g \times \frac{1 \text{ mol LiCN}}{32.96g} = 0.01081 \text{ mol LiCN} / 0.9981L = 0.01083 \text{ M LiCN}$ (1 pt)

$LiCN \xrightarrow{H_2O} Li^+ + \mathbf{CN^-}$ Therefore: [CN-] = 0.01083 (1 pt)

(neutral) **(Basic)**

2 pts $CN^- + H_2O \leftrightarrow HCN + OH^-$ (Basic RXN – need $K_b$)

| | | | |
|---|---|---|---|
| I | 0.01083 | 0 | 0 |
| C | -X | +X | +X |
| E | 0.01083 – X | X | X |

$K_w = K_a K_b$

$1.0 \times 10^{-14} = (4.9 \times 10^{-10})K_b$

$K_b = 2.0 \times 10^{-5}$ (1 pt)

$K_b = \frac{[HCN][OH^-]}{[CN^-]}$ (-3 for $K_a$ instead of $K_b$)

$2.0 \times 10^{-5} = \frac{(x)(x)}{0.01083-x}$ → 0

$\sqrt{2.2 \times 10^{-7}} = \sqrt{x^2}$

1 pt $\boldsymbol{x = 4.7 \times 10^{-4} M = [OH^-]}$

$pOH = -\log(4.7 \times 10^{-4}) = 3.33$ (1 pt)

$pH = 14 - pOH = 14 - 3.33 =$ **10.67** (1 pt)

27) (6 pts) What is the pH of a solution made by adding 0.025 M hypobromous acid (HOBr) to 0.010 M sodium hypobromite (NaOBr)? Assume no volume change. **$K_a$ = 2.0 x $10^{-9}$**

**pH = _____**

Can do by H-H equation:

$$pH = pK_a + log\frac{[A^-]}{[HA]}$$

$$pH = 8.70 + log\frac{[0.010]}{[0.025]}$$ 2 pts 2 pts

$$\boxed{pH = 8.30}$$ (2 pts)

Can do by ICE table:

$$HOBr + H_2O \leftrightarrow H_3O^+ + OBr^-$$ 3 pts

| | | | |
|---|---|---|---|
| I | 0.025 | 0 | 0.010 |
| C | -X | +X | +X |
| E | 0.025– X | X | 0.010+X |

$$K_a = \frac{[H_3O^+][OBr^-]}{[HOBr]}$$

$$2.0 \times 10^{-9} = \frac{(x)(0.010+x)}{(0.025-x)}$$ (0.010+x → 0; 0.025−x → 0)

$$2.0 \times 10^{-9} = \frac{(x)(0.010)}{(0.025)}$$

$$x = 5.0 \times 10^{-9} M = [H_3O^+]$$ 1 pt

$$pH = -log(5.0 \times 10^{-9}) = \boxed{8.30}$$ 2 pts

28) (2 pts) When some HCl is added to the solution in number 27, the pH barely changes because:

a. The $OBr^-$ ion neutralizes the $H^+$ and produces HOBr.
b. The common ion effect.
c. The HOBr neutralizes the HCl and produces more conjugate base.
d. The conjugate base $OH^-$ absorbs the HCl.
e. The $Na^+$ ion neutralizes the HCl and produces NaCl.

29) (4 pts) What is the pH of a solution made by adding 25.00 mL of 0.20 M NaOH to 25.00 mL of 0.20 M HCl?

a. pH = 0.00
b. pH = 1.00
c. pH = 7.00
d. pH = 9.00
e. pH = 13.00

Equal amounts of strong acid and strong base → equivalence pt. Therefore the pH is 7. No calculation needed!

(-1 for no work or explanation)

30) (4 pts) What volume (in mL) of 0.351 M KOH is needed to reach the equivalence point when it is titrated with 20.00 mL of 0.452 M acetic acid ($CH_3COOH$)? (Stoichiometry!!!!)

a. 7.93 mL
b. 15.0 mL
c. 20.0 mL
d. 25.8 mL
e. 35.1 mL

$$CH_3COOH + KOH \leftrightarrow H_2O + KCH_3COO$$

$$0.02000\cancel{L} \times \frac{0.425\ \cancel{mol\ CH_3COOH}}{1\cancel{L}} \times \frac{1\ \cancel{mol\ KOH}}{1\ \cancel{mol\ CH_3COOH}} \times \frac{1\cancel{L}}{0.351\ \cancel{mol\ KOH}} \times \frac{1000mL}{1\cancel{L}} = \boxed{25.8\ mL\ KOH}$$

1 pt 1 pt 1 pt 1 pt

(- 3 for using $M_1V_1=M_2V_2$)

31) (4 pts) Which of the following salts is **least soluble** in pure water?

a. CuS, $K_{sp} = 6.3 \times 10^{-36} = (S)(S) \rightarrow S = \sqrt{6.3 \times 10^{-36}} = 2.5 \times 10^{-18}$

b. $Sn(OH)_2$, $K_{sp} = 5.4 \times 10^{-27} = (S)(2S)^2 \rightarrow S = \sqrt[3]{\frac{5.4 \times 10^{-27}}{4}} = 1.1 \times 10^{-9}$

c. AgCN, $K_{sp} = 6.0 \times 10^{-17} = (S)(S) \rightarrow S = \sqrt{6.0 \times 10^{-17}} = 7.7 \times 10^{-9}$

32) (7 pts) Write the chemical reaction for the dissolution of iron(II) hydroxide in water. Then write the $K_{sp}$ expression for this salt.

Reaction: $Fe(OH)_{2(s)} \leftrightarrow Fe^{2+}_{(aq)} + 2OH^-_{(aq)}$ (1 pt) (1 pt) (1 pt)

$K_{sp} = [Fe^{2+}][OH^-]^2$ (2 pts)

-1 for $Fe(OH)_2$
-1 for not squaring $OH^-$

Calculate the molar solubility (S) of iron (II) hydroxide if $K_{sp} = 4.9 \times 10^{-17}$.

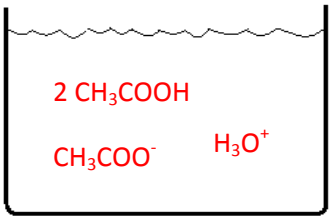
$$K_{sp} = (S)(2S)^2 \quad (1 \text{ pt})$$

$$\sqrt[3]{\frac{4.9 \times 10^{-17}}{4}} = \sqrt[3]{\frac{4S^3}{4}}$$

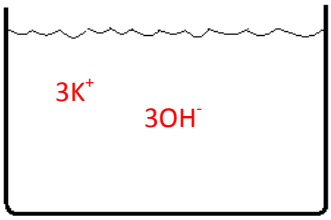
$$\boldsymbol{S = 2.3 \times 10^{-6}\ M} \quad (1 \text{ pt})$$

**Bonus:** Draw what the resulting solutions will look like when the following chemicals are put in water:

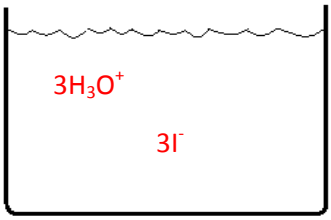
acetic acid




potassium hydroxide




Hydroiodic acid




1 pt each

**Bonus:** What is the definition of the First Law of Thermodynamics? (2 pts)

Cannot create nor destroy Energy!!!