MULTIPLE CHOICE. (1 point each) Choose the one alternative that best completes the statement or answers the question.

1) An acetate buffer has a pH of 4.40. Which of the following changes will cause the pH to decrease?

    A) adding a small amount of dilute sodium hydroxide
    B) adding a small amount of dilute hydrochloric acid
    C) dissolving a small amount of solid sodium chloride
    D) diluting the buffer solution with water
    E) dissolving a small amount of solid sodium acetate

1) _B_

2) Which of the following has the highest buffer capacity?

    A) 0.50 M $H_2PO_4^-$/0.10 M HPO_4^{2-}
    B) 0.50 M $H_2PO_4^-$/0.50 M HPO_4^{2-}
    C) 0.10 M $H_2PO_4^-$/0.10 M HPO_4^{2-}
    D) 0.10 M $H_2PO_4^-$/0.50 M HPO_4^{2-}
    E) They all have the same buffer capacity.

2) _B_

3) Which of the following substances has the greatest solubility in water?

    A) CuBr, K_{sp} = 5.0 × 10^{-9}
    B) NiCO$_3$, K_{sp} = 1.3 × 10^{-7}
    C) MgCO$_3$, K_{sp} = 3.5 × 10^{-8}
    D) AgCN, K_{sp} = 2.2 × 10^{-16}
    E) AgIO$_3$, K_{sp} = 3.1 × 10^{-8}

3) _B_

4) What is the value of K_b for the formate anion, HCOO$^-$? K_a(HCOOH) = 2.1 × 10^{-4}

    A) −2.1 × 10^{-4}
    B) 6.9 × 10^{-6}
    C) 4.8 × 10^{-11}
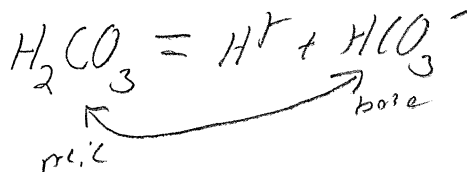   D) 2.1 × 10^{-4}
    E) 2.1 × 10^{-18}

4) _C_

$$K_a K_b = K_w$$

$$K_b = \frac{10^{-14}}{2.1 \times 10^{-4}} = 4.8 \times 10^{-11}$$

1

5) Which, if any, of the following aqueous mixtures would be a buffer system?   5) ___D___

   A) $H_2PO_4^-$, HCO_3^-
   B) CH_3COOH, NaH_2PO_4
   C) HSO_4^-, HSO_3^-
   D) H_2CO_3, HCO_3^-
   E) None of these choices are correct.

$$H_2CO_3 = H^+ + HCO_3^-$$
acid → base
← acid

6) What is the pH of a 0.050 *M* HBr solution?   6) ___A___

   A) 1.30
   B) 0.89
   C) 3.00
   D) 1.12
   E) None of these choices are correct.

$$pH = -\log(0.050) = 1.30$$

7) A 20.0-mL sample of 0.30 *M* HClO was titrated with 0.30 *M* NaOH. The following data were collected during the titration.   7) ___A___

mL NaOH added	5.00	10.00	1.00	2.00
pH	6.98	7.46	7.93	10.31

What is the K_a for HClO?

   A) 3.5×10^{-8}
   B) 1.1×10^{-7}
   C) 1.2×10^{-8}
   D) 4.9×10^{-11}
   E) None of these choices are correct.

Half-way to Eq. point

$$pH = pK_a$$

10 mL added pH = 7.46

so $pK_a = 7.46$

$$K_a = 10^{-pK_a} = 3.5 \times 10^{-8}$$

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8) What is the pK_a for the acid HA if a solution of 0.65 M HA and 0.85 M NaA has a pH of 4.75?

    8) _____ B

   A) > 5.50   B) 4.63   C) 4.87   D) 5.02   E) < 4.00

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

$$pK_a = pH - \log \frac{[A^-]}{[HA]} = 4.75 - \log \frac{(0.85)}{(0.65)} = 4.63$$

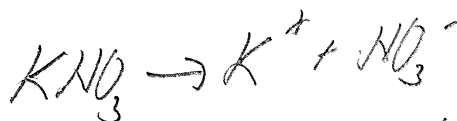9) Which one of the following substances will give an aqueous solution of pH closest to 7?

    9) _____ E

   A) CO_2
   B) NH_4I
   C) NH_3
   D) CH_3NH_2
   E) KNO_3

$$KNO_3 \rightarrow K^+ + NO_3^-$$

strong Acid/strong base conj.

10) A solution is prepared by adding 0.10 mol of potassium chloride, KCl, to 1.00 L of water. Which statement about the solution is correct?

    10) _____ B

   A) The solution is acidic.
   B) The solution is neutral.
   C) The solution is basic.
   D) One needs to know the temperature before any of these predictions can be made.
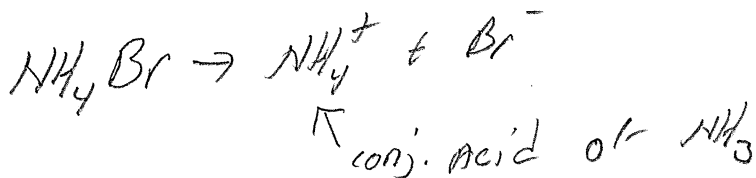   E) The values for K_a and K_b for the species in solution must be known before a prediction can be made.

$$KCl \rightarrow K^+ + Cl^-$$

As above

11) Which one of the following substances will give an aqueous solution of pH < 7?　　11) $\underline{C}$

    A) CH_3COONa
    B) CH_3OH
    C) NH_4Br
    D) Na_2CO_3
    E) KI

$NH_4Br \rightarrow NH_4^+ + Br^-$
              ↖ conj. acid of NH_3

12) A 0.15 M solution of chloroacetic acid has a pH of 1.86. What is the value of K_a for this acid?　　12) $\underline{B}$

    A) 0.00027
    B) 0.0014
    C) 0.16
    D) 7.2×10^1
    E) 0.099

$HA \rightleftharpoons H^+ + A^-$

0.15	0	0
$-x$	$+x$	$+x$
$0.15-x$	x	x
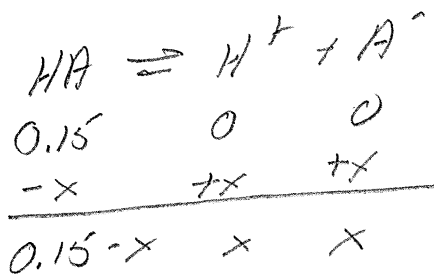
$[H^+] = 10^{-1.86}$
$= 1.38 \times 10^{-2}$

$$K_a = \frac{(x)(x)}{(0.15-x)} = \frac{(1.38 \times 10^{-2})^2}{(0.15 - 1.38 \times 10^{-2})} = 1.39 \times 10^{-3}$$

$$= \underline{0.0014}$$

13) What is the pH of a buffer that consists of 0.45 M CH_3COOH and 0.35 M CH_3COONa?　　13) $\underline{B}$
$K_a = 1.8 \times 10^{-5}$

    A) 4.85   B) 4.64   C) 5.52   D) 5.00   E) 4.49

$$pH = -\log(1.8 \times 10^{-5}) + \log\left(\frac{0.35}{0.45}\right) = 4.64$$

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14) Which of the following acids should be used to prepare a buffer with a pH of 4.5?   14) _A_

  A) CH_3COOH, $K_a = 1.8 \times 10^{-5}$ ← closest
  B) HBrO, $K_a = 2.3 \times 10^{-9}$
  C) HOC_6H_4OCOOH, $K_a = 1.0 \times 10^{-3}$
  D) $C_5H_5O_5COOH$, $K_a = 4.0 \times 10^{-6}$
  E) $C_6H_4(COOH)_2$, $K_a = 2.9 \times 10^{-4}$

want $pK_a \approx 4.5$

so $K_a \approx 10^{-4.5}$

$\approx 3.2 \times 10^{-5}$

15) What is the pH of a 0.050 M LiOH solution?   15) _C_

  A) 11.00   B) < 1.0   C) 12.70   D) 3.00   E) 1.30

$pOH = -\log(0.050) = 1.30$

$pH = 12.70$

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SHORT ANSWER. (5 points each) Write the word or phrase that best completes each statement or answers the question. Must show all work for credit

16) If 10.0 g of NaF and 20.0 g of HF are dissolved in water to make one liter of solution, what will the pH be? For HF, $K_a = 6.8 \times 10^{-4}$.

16) $\underline{2.54}$

$$10.0_g \; NaF \times \frac{1 \, mol \; NaF}{42.0_g \; NaF} = 2.38 \times 10^{-1} \; mol \; NaF \qquad M \; of \; NaF = \frac{0.238 \, mol}{1 \, L}$$

$$20.0_g \; HF \times \frac{1 \, mol \; HF}{20.008_g \, HF} = 0.9996 \; mol \; HF \qquad M = \frac{0.9996 \, mol}{1 \, L}$$

$$HF = H^+ + F^-$$
$$1.0 \, M \qquad\qquad 0.238 \, M$$
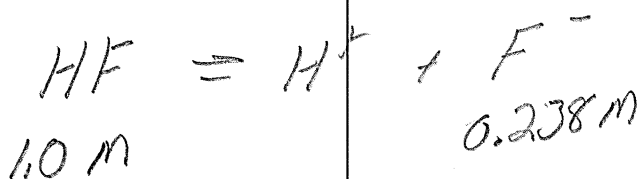
$$pH = - \log(6.8 \times 10^{-4}) + \log\left(\frac{0.238}{1.0}\right) = \underline{2.54}$$
$$3.17 \qquad\qquad - 0.62 \qquad =$$

6

17) The solubility of lead(II) chloride is 0.45 g/100 mL of solution. What is the K_{sp} o   17) $\underline{1.69 \times 10^{-5}}$
PbCl$_2$?

$$\frac{0.45_g \, PbCl_2}{100 \, mL} \times \frac{1 \, mol \, PbCl_2}{278.10_g \, PbCl_2} \times \frac{1000 \, mL}{1 \, L} = 1.62 \times 10^{-2} \frac{mol}{L}$$

$$PbCl_{2(s)} \rightleftharpoons Pb^{2+} + 2Cl^-$$

I		0	0
-x		+x	+2x
		x	2x
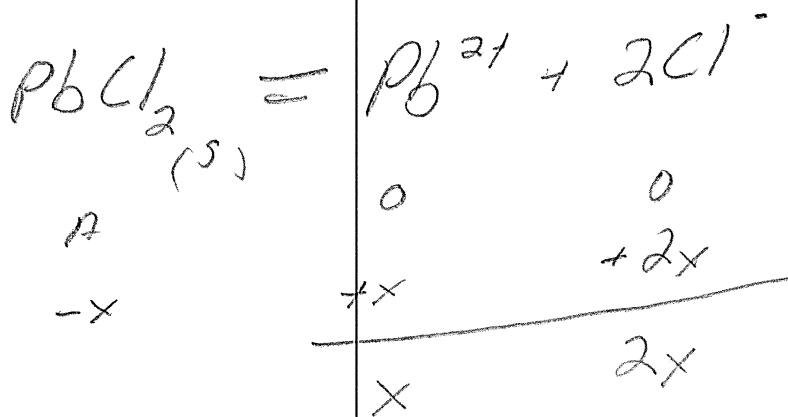
$$K_{sp} = (x)(2x)^2 = 4x^3$$
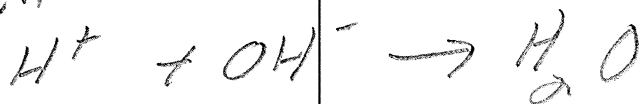$$= 4(1.62 \times 10^{-2})^3 = \underline{1.69 \times 10^{-5}}$$

18) A 50.0-mL sample of 0.50 M HCl is titrated with 0.50 M NaOH. What is the pH   18) __0.85__
of the solution after 28.0 mL of NaOH have been added to the acid?

$$50.0 \, mL \times \frac{0.50 \, mol \, HCl}{1000 \, mL} = 2.5 \times 10^{-2} \, mol \, H^+$$

$$28.0 \, mL \times \frac{0.50 \, mol \, NaOH}{1000 \, mL} = 1.4 \times 10^{-2} \, mol \, OH^-$$

stoich.
$$H^+ + OH^- \rightarrow H_2O$$
0.025   0.014

0.025 - 0.014   0
= 0.011 mol H⁺ left

$$M = \frac{0.011 \, mol \, H^+}{\left(\frac{50 + 28}{1000}\right) L} = 0.141 = [H^+]$$

pH = 0.85

1) B
2) B
3) B
4) C
5) D
6) A
7) A
8) B
9) E
10) B
11) C
12) B
13) B
14) A
15) C
16) 2.54
17) 1.7×10^{-5}
18) 0.85