

**GENERAL CHEMISTRY 2
THIRD HOUR EXAM**

Name _____

Panthersoft ID _____

Signature _____

Part 1 _____ (20 points)

Part 2 _____ (22 points)

Part 3 _____ (38 points)

TOTAL _____ (80 points)

Do all of the following problems. Show your work.

Part 1. Multiple choice. Circle the letter corresponding to the correct answer. There is one and only one correct answer per problem. [4 points each]

The following information will be of use in doing problems 1 and 2 below.

Weak acid	K_a	Weak acid	K_a
benzoic acid (C_6H_5COOH)	6.5×10^{-5}	nitrous acid (HNO_2)	4.5×10^{-4}
chloroacetic acid ($CH_2ClCOOH$)	1.4×10^{-3}	phenol (C_6H_5OH)	1.3×10^{-10}

1) Which of the following 0.0100 M solutions of weak acid will have the lowest value for pH?

- a) a 0.0100 M solution of benzoic acid
- b) a 0.0100 M solution of chloroacetic acid
- B** c) a 0.0100 M solution of nitrous acid
- d) a 0.0100 M solution of phenol
- e) All of the above solutions will have the same value for pH

2) Which of the following 0.0100 M solutions of the sodium salt of the conjugate base of a weak acid will have the highest value for pH?

- a) a 0.0100 M solution of sodium benzoate (NaC_6H_5COO)
- b) a 0.0100 M solution of sodium chloroacetate ($NaCH_2ClCOO$)
- D** c) a 0.0100 M solution of sodium nitrite ($NaNO_2$)
- d) a 0.0100 M solution of sodium phenolate (NaC_6H_5O)
- e) All of the above solutions will have the same value for pH

3) Ammonium perchlorate (NH_4ClO_4) is a soluble salt formed by the reaction of a strong acid with a weak base. The pH of a 0.100 M solution of ammonium perchlorate, measured at $T = 25.^\circ C$, is expected to be

- a) exactly equal to 7.0
- b) significantly larger than 7.0
- D** c) approximately equal to 7.0
- d) significantly smaller than 7.0
- e) undefined, because the concept of pH does not apply to solutions of salts

4) Which of the following metal ions would be expected to be the strongest weak acid?

- a) Al^{3+} ion
- b) Ba^{2+} ion
- A** c) Cs^+ ion
- d) Cu^{2+} ion
- e) Pb^{2+} ion

5) Which of the following reactions is expected to go to completion?

- a) The reaction of a strong acid with a strong base
- b) The reaction of a strong acid with a weak base
- E** c) The reaction of a weak acid with a strong base
- d) Both a and b
- e) Both a and b and c

Part 2. Short answer.

1) For each of the following circle the correct answer. There is one and only one correct answer per problem. [3 points each]

a) A polyprotic acid

HCl HIO₂ HNO₃ H₂SO₄

b) The strongest acid from the following acids

HBrO₂ HBrO₃ HIO₂ HIO₃

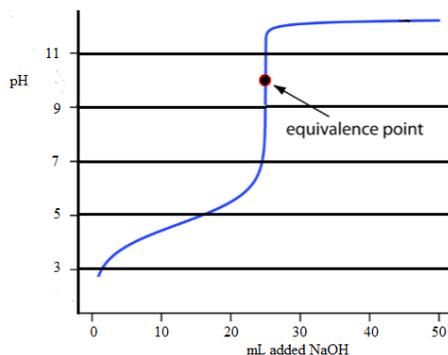
c) The strongest acid from the following acids

H₂S H₂O HBr HF

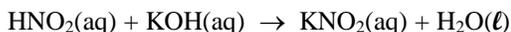
2) What is the difference (if any) between the equivalence point and the end point of an acid/base titration? [5 points]

The equivalence point in an acid/base titration is the point where the amount of titrant added to the sample solution is just enough for the complete neutralization reaction to occur, with no excess of either the acid or the base. The end point in an acid/base titration is the point where the indicator used to monitor the reaction changes color. An indicator is chosen for acid/base titrations so that the amount of titrant added to reach the end point is as close as possible to the volume needed to reach the equivalence point.

3) The figure below is for the titration of a 25.00 mL sample of nitrous acid (HNO₂, a weak acid) with a 0.2482 M solution of potassium hydroxide (KOH, a strong soluble base).



a) Give the balanced molecular equation corresponding to the neutralization reaction in the above titration. [4 points]



b) Which of the following indicators would be the best choice to use in the above titration (circle the correct answer). [4 points]

bromophenol blue
pK_a = 3.8

methyl red
pK_a = 5.2

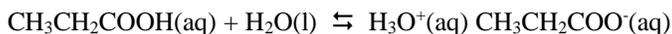
bromothymol blue
pK_a = 6.6

phenolphthalein
pK_a = 9.0

Part 3. Problems.

1) Propanoic acid ($\text{CH}_3\text{CH}_2\text{COOH}$, MW = 74.08 g/mol) is a weak monoprotic acid, with $K_a = 1.34 \times 10^{-5}$.

a) A chemist prepares 1.000 L of a 0.0360 M aqueous solution of propanoic acid. What is the pH of the solution? [12 points]



$$K_a = \frac{[\text{H}_3\text{O}^+][\text{CH}_3\text{CH}_2\text{COO}^-]}{[\text{CH}_3\text{CH}_2\text{COOH}]} = 1.34 \times 10^{-5}$$

	Initial	Change	Equilibrium		
H_3O^+	0	x	x	So	$\frac{(x)(x)}{(0.0360 - x)}$
$\text{CH}_3\text{CH}_2\text{COO}^-$	0	x	x		1.34×10^{-5}
$\text{CH}_3\text{CH}_2\text{COOH}$	0.0360	- x	0.0360 - x		
Assume $x \ll 0.0360$		Then	$\frac{x^2}{0.0360} = 1.34 \times 10^{-5}$		$x^2 = (0.0360)(1.34 \times 10^{-5}) = 4.82 \times 10^{-7}$
					$x = (4.82 \times 10^{-7})^{1/2} = 6.95 \times 10^{-4}$

The assumption that x was small was good.

$$[\text{H}_3\text{O}^+] = x = 6.95 \times 10^{-4}$$

$$\text{pH} = -\log_{10}(6.95 \times 10^{-4}) = 3.16$$

b) 0.500 g of sodium hydroxide (NaOH, MW = 40.00 g/mol) is added to the above 1.000 L solution of propanoic acid. What is the new value for pH after the addition of the sodium hydroxide? You may assume that the addition of NaOH does not change the volume of the solution. [12 points]



$$\text{initial moles NaOH} = 0.500 \text{ g} \times \frac{1 \text{ mol}}{40.00 \text{ g}} = 0.0125 \text{ mol NaOH}$$

$$\text{initial moles CH}_3\text{CH}_2\text{COOH} = 1.000 \text{ L soln} \times \frac{0.0360 \text{ mol}}{\text{L soln}} = 0.0360 \text{ moles CH}_3\text{CH}_2\text{COOH}$$

After neutralization, the moles of $\text{CH}_3\text{CH}_2\text{COOH}$ is $0.0360 \text{ moles} - 0.0125 \text{ moles} = 0.0235 \text{ moles}$

The reaction produces conjugate base, so after the neutralization we have 0.0125 moles $\text{CH}_3\text{CH}_2\text{COO}^-$

We can use the Henderson equation to find the pH

$$\begin{aligned} \text{pH} &= \text{p}K_a + \log_{10}\{\text{base/acid}\} = -\log_{10}(1.34 \times 10^{-5}) + \log_{10}\{0.0125/0.0235\} \\ &= 4.87 + (-0.27) = 4.60 \end{aligned}$$

2) A 25.00 mL sample of an aqueous stock solution of potassium hydroxide (KOH, MW = 56.11 g/mol) is titrated with a 0.2281 M aqueous solution of hydrochloric acid (HCl, MW = 36.46 g/mol) at T = 25. °C. After the addition of 23.04 mL of the HCl solution the equivalence point for the titration is reached.

a) What is the concentration of the stock solution of potassium hydroxide? [10 points]

reaction is $\text{HCl} + \text{KOH} \rightarrow \text{H}_2\text{O} + \text{KCl}$

$$\text{moles HCl} = 0.02304 \text{ L soln} \frac{0.2281 \text{ mol}}{\text{L soln}} = 5.255 \times 10^{-3} \text{ mol HCl}$$

From the balanced equation, moles KOH = moles HCl = 5.255×10^{-3} mol

$$\text{So } [\text{KOH}] = \frac{5.255 \times 10^{-3} \text{ mol KOH}}{0.02500 \text{ L soln}} = 0.2102 \text{ M}$$

b) What is the pH at the equivalence point of the titration (circle the correct answer)? [4 points]

greater than 7.0

equal to 7.0

less than 7.0