Chem 105 Exam 5 Key

This exam is due Monday December 7th at 8:00 AM. **Late work will NOT be accepted**.

If you worked with anyone, please list their names below:

Your name _____ Group member _____

Group member _____ Group member _____

By signing here, I certify that the work here is reflective of the work done by me and my group, which is listed above. I did not receive help from resources that are not part of this course.

You must sign to receive credit for this exam.

Signature _____ Date _____

1. What is the difference between a strong acid and a weak acid?

react to completion ; governed by equilibrium

2. What does the term "conjugate base" mean?

- when a Bronsted-Lowry acid reacts with a base, it gets deprotonated
The resulting molecule is a conjugate base

3. What is a base dissociation reaction?

a base reacting with water
hydroxide is always produced $A^- + H_2O \rightleftharpoons HA + OH^-$

4. Mercaptoethanol has a pKa of 9.643. Determine each of the following:
   a. Ka $10^{-9.643} = 2.275 \times 10^{-10}$
   b. pKb of the conjugate base $14 - 9.643 = 4.357$
   c. Kb of the conjugate base $10^{-4.357} = 4.395 \times 10^{-5}$
   d. What is the maximum and minimum pH that can be buffered by mercaptoethanol?

10.643 ; 8.643

5. Calculate the pH and pOH of 1.685 mM $KHSO_4$.

K^+ ; HSO_4^-

$HSO_4^- + H_2O_{(l)} \rightleftharpoons H_3O^+ + SO_4^{2-}$

	HSO_4^-		H_3O^+	SO_4^{2-}
I	0.001685		0	0
C	$-x$		$+x$	$+x$
E	$0.001685 - x$		x	x

$K_a = 1 \times 10^{-2} = \frac{x^2}{0.001685 - x}$

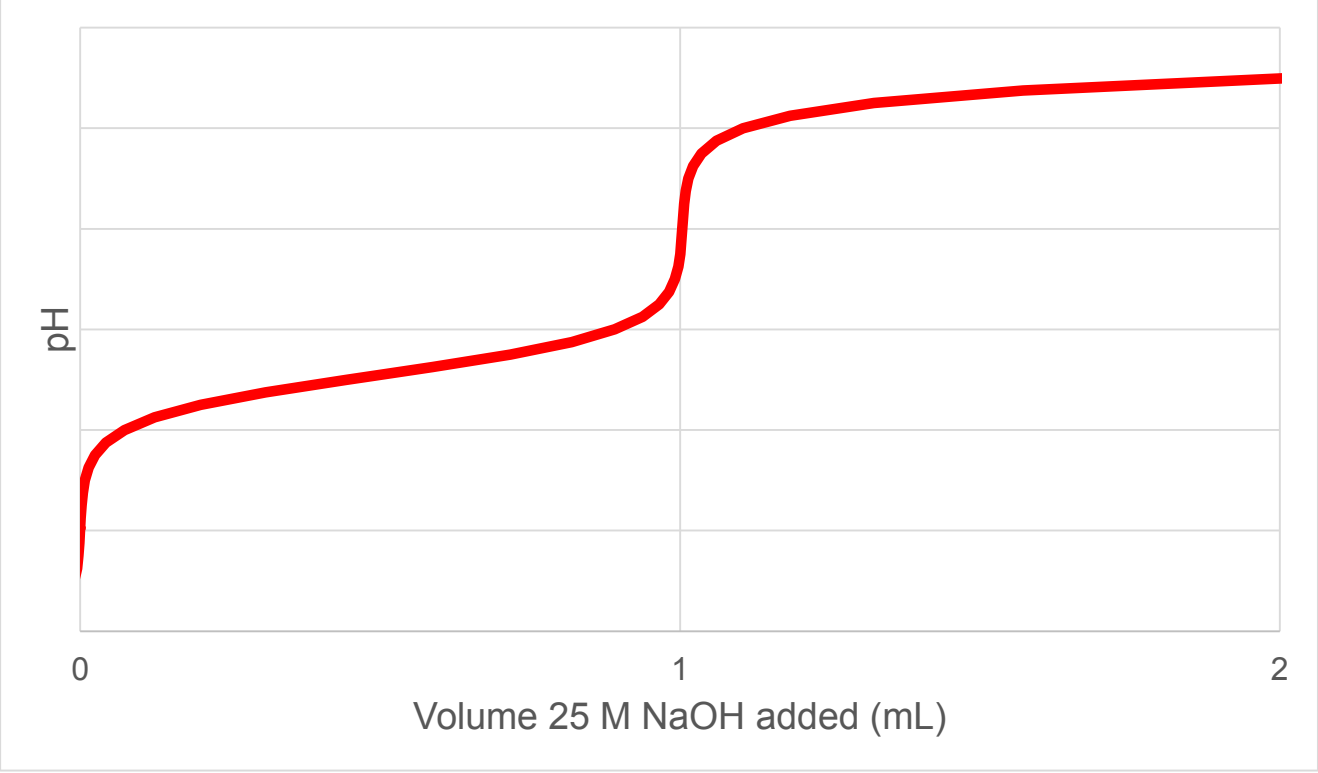
$0 = x^2 + 1 \times 10^{-2} x - 1.685 \times 10^{-5}$

$x = [H_3O^+] = 0.001469\ M$

$pH = -\log 0.001469 = 2.83$

$pOH = 14 - pH = 11.17$

6. The titration curve below shows the addition of 25 M NaOH to 250 mL of 100 mM weak acid with a pKa of 7.1. Determine each of the following:
   a. Initial pH See below
   b. pH at the ½ equivalence point $pH = pK_a = 7.1$
   c. pH at the equivalence point See below



a) $HA + H_2O \rightleftharpoons A^- + H_3O^+$

	HA	A^-	H_3O^+
I	0.1	0	0
C	$-x$	$+x$	$+x$
E	$0.1-x$	x	x

$$10^{-7.1} = \frac{x^2}{0.1-x}$$

$$0 = x^2 + 10^{-7.1}x - 10^{-8.1}$$

$x = [H_3O^+] = 8.909 \times 10^{-5}$ M

Initial pH $= -\log 8.909 \times 10^{-5} = 4.05$

c) @ Eq. Pt. All $HA \rightarrow A^-$

$$0.25\text{L}\left(\frac{0.1\text{ mol}}{\text{L}}\right) = \frac{0.025\text{ mol } A^-}{0.25\text{ L} + 0.001\text{ L}} = 0.0996$$

$A^- + H_2O \rightleftharpoons HA + OH^-$

	A^-	HA	OH^-
I	0.0996	0	0
C	$-x$	$+x$	$+x$
E	$0.0996-x$	x	x

$pK_b = 14 - 7.1 = 6.9$

$$10^{-6.9} = K_b = \frac{x^2}{0.0996-x}$$

$$0 = x^2 + 10^{-6.9}x - 1.254 \times 10^{-8}$$

$x = [OH^-] = 1.119 \times 10^{-4}$ M

pOH = 3.95

pH = 14 − 3.95 = 10.05

7. What concentration of perchloric acid is needed to have a solution with a pH of 2.86?

↑ strong acid

$pH = 2.86$

$[H_3O^+] = 10^{-2.86}$

$[HClO_4] = 1.38 \times 10^{-3}\ M$

8. Consider a 600 mL solution that contains 28 mM ammonia and 32 mM ammonium.
   a. What is the pH of this solution?

$pK_a = 9.25$

$pH = 9.25 + \log \frac{28}{32} = 9.19$

   b. Calculate the pH if 3.4 mL of 2.6 M $Mg(OH)_2$ is added.

OH^-: $\frac{3.4\ mL}{} \left| \frac{10^{-3}\ L}{1\ mL} \right| \frac{2.6\ mol\ Mg(OH)_2}{L} \left| \frac{2\ mol\ OH^-}{1\ mol\ Mg(OH)_2} \right. = 0.01768\ mol\ OH^-$

HA: $0.6\ L \left| \frac{32\ mmol}{L} \right| \frac{10^{-3}\ mol}{1\ mmol} = 0.0192\ mol\ HA$

A^-: $0.6\ L \left| \frac{28\ mmol}{L} \right| \frac{10^{-3}\ mol}{mmol} = 0.0168\ mol\ A^-$

	HA	$+ OH^-$	$\longrightarrow A^-$	$+ H_2O$
I	0.0192	0.01768	0.0168	
C	−0.01768	−0.01768	+0.01768	
E	0.00152	Ø	0.03448	

$pH = 9.25 + \log \frac{0.03448}{0.00152} = 10.61$ *

* See below

9. Consider a 600 mL solution that contains 28 mM ammonia and 32 mM ammonium. How many moles of nitric acid can be added to this solution and still be within the buffer range?

$NH_3 + HCl \longrightarrow NH_4^+ + Cl^-$

	NH_3	$+ HCl$	$\longrightarrow NH_4^+$	$+ Cl^-$
I	0.0168	x	0.0192	
C	−x	−x	+x	
E	0.0168 − x	Ø	0.0192 + x	
	A^-		HA	

$8.75 = 9.25 + \log \frac{A^-}{HA}$

$\frac{A^-}{HA} = 0.1$

$\frac{0.0168 - x}{0.0192 + x} = 0.1$

$0.0168 - x = 0.00192 + 0.1x$

$0.01488 = 1.1x$

$x = 0.0135\ mol$

* Note that this is outside the buffer range & Henderson-Hasselbalch should not have been used. However, this is due to a typo on my part (it should have been 1.4 mL, not 14)

-Full credit is awarded if you did it the way above. Below is the correct way:

$[HA] = \frac{0.00152}{0.6+0.00214} = 0.0025$ $\quad [A^-] = \frac{0.03444}{0.6+0.00214} = 0.05714$

	HA	$+ H_2O \rightleftharpoons$	A^-	$+ H_3O^+$
I	0.0025		0.05714	0
C	$-x$		$+x$	$+x$
E	$0.0025-x$		$0.05714+x$	x

$$10^{-9.25} = \frac{0.05714x + x^2}{0.0025 - x}$$

$$1.4059\times10^{-12} - 10^{-9.25}x = 0.05714x + x^2$$

$$0 = x^2 + 0.05714x - 1.4059\times10^{-12}$$

$$x = [H_3O^+] = 2.46\times10^{-11}$$

$$pH = 10.61$$