Chemistry 271, Section 22xx **Your Name:** _____

Prof. Jason Kahn

University of Maryland, College Park **Your SID #:** _____

General Chemistry and Energetics **Your Section #:** _____

Exam I (100 points total) **February 29, 2012**

You have 50 minutes for this exam.

Exams written in pencil or erasable ink will not be re-graded under any circumstances.

Explanations should be concise and clear. I have given you more space than you should need. There is extra space on the last page if you need it.

You will need a calculator for this exam. No other study aids or materials are permitted.

Partial credit will be given, *i.e.*, if you don't know, guess.

Useful Equations:

$K_a = [H^+][A^-]/[HA]$ $\quad$ $pH = -\log([H^+])$ $\quad$ $K_b = [BH^+][HO^-]/[B]$

$F = ma$ $\quad$ $e^{i\pi} + 1 = 0$ $\quad$ $PV = nRT$

$K_w = [H^+][HO^-] = 10^{-14}$ $\quad$ $pH = pK_a + \log([A^-]/[HA])$ $\quad$ pH (e.p.) = $(pK_{a1} + pK_{a2})/2$

$R = 0.08206$ L·atm/mole K $\quad$ 0 °C = 273.15 K $\quad$ $pK_a = -\log(K_a)$

$K_p = K_c(RT)^{\Delta n}$ $\quad$ $P^2/a^3 = 4\pi^2/MG$ $\quad$ $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Honor Pledge: At the end of the examination time, please write out the following sentence and sign it, or talk to me about it:

"I pledge on my honor that I have not given or received any unauthorized assistance on this examination."

+1 point extra credit for filling in this box

1. (30 pts) Short Answer

(a; 2 pts) pH of 0.1 M HCl_____

(b; 2 pts) pOH of 0.001 M NaOH_____

(c; 4 pts) The water self-dissociation equilibrium is _____, its equilibrium constant is symbolized by_____, and the numerical value of the equilibrium constant at 25 °C is_____.

(d; 2 pts) $[H^+]$ at pH 5.5_____ (in scientific notation).

(e; 2 pts) $[OH^-]$ at pH 10.3_____ (in scientific notation).

(f; 4 pts) Write down Q in terms of partial pressures for the reaction C (s) + H_2O (g) ⇋ CO (s) + H_2 (g) :

(g; 4 pts) We can use the Henderson-Hasselbach relationship as a shortcut for calculating pH if and only if

_____.

(h; 3 pts) The pI is equal to the pH at the equivalence point of a polyprotic acid titration for which

_____.

(i; 2 pts) At equilibrium the rates of the forward and reverse reactions are

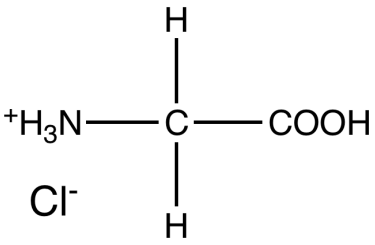
(circle one): zero equal unrelated

(j; 5 pts) Circle the correct choice in each pair: Real gases approach ideal behavior as the temperature goes up down and the pressure goes up down because under these conditions intermolecular interactions are minimized stabilized and the total excluded volume is larger smaller. The formula for the ideal gas law is _____.

Score for the page_____

2. (45 pts) Acid-Base Equilibria and Titrations

Consider a titration of the diprotic acid glycine, with pKa's of 2.36 and 9.78. The structure of the fully protonated form as the chloride salt is given at the right. We are starting with a C_0 = 75 mM solution of this form.



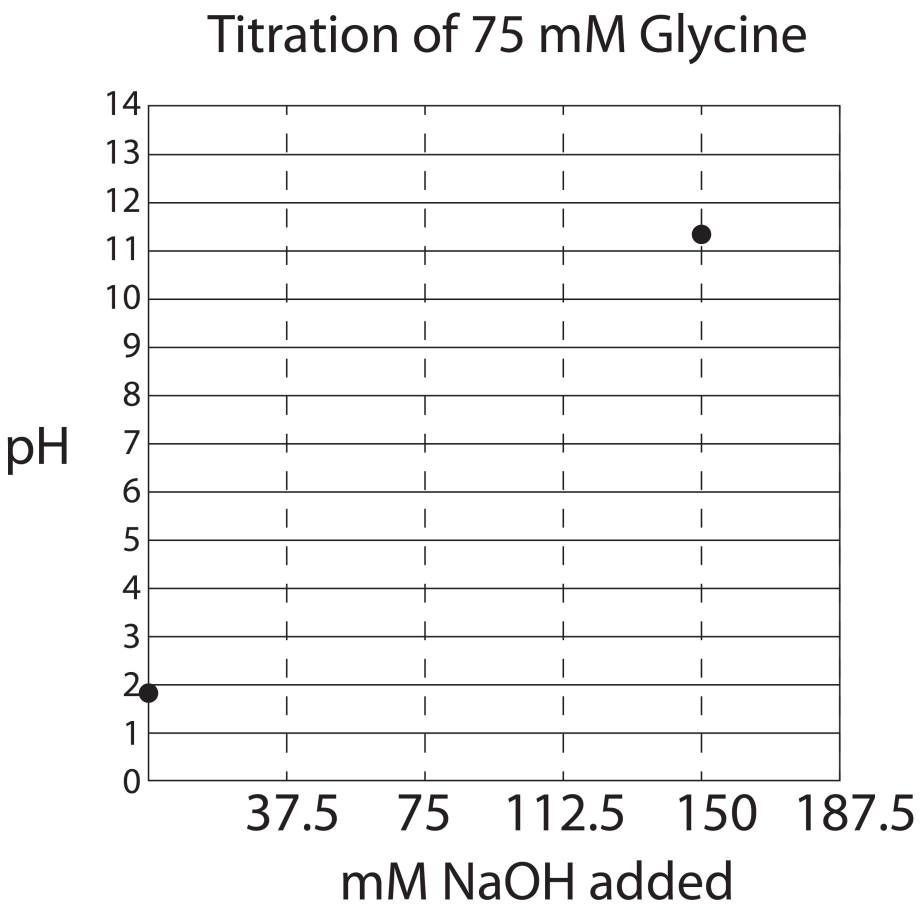
(a; 10 pts) Calculate the initial pH assuming "*x*" is small relative to C_0. Physically, why does this turns out to be a fairly lousy assumption? The actual pH is 1.79.

(b; 12 pts) What is the pH after addition of NaOH to 50 mM, ignoring dilution? At this pH, what fraction of the $-NH_3^+$ groups are found in the $-NH_2$ form? Why is the precise numerical value of the second pK_a (i.e. 9.78 as opposed to ~8 or ~11) irrelevant to the pH at this point in the titration?

Score for the page_____

(c; 11 pts) Draw the dominant ionic form of glycine at the second equivalence point, i.e. after the addition of NaOH to 150 mM. Calculate the K_b for this relatively strong weak base. Write down but do not evaluate the quadratic formula for the concentration of hydroxide at this equivalence point. The actual pH is 11.32.

(d; 12 pts) Sketch the titration curve for 75 mM glycine on the axes at the right, ignoring dilution. Label the two half-equivalence points, the pI, and the part of the curve where we are just "adding base to salt." At a pH just below the pI, draw the second most abundant form of glycine below.



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4. (25 pts) Chemical Equilibrium (Problem adapted from Oxtoby)

The equilibrium constant for the reaction $H_2\,(g) + I_2\,(s) \leftrightharpoons 2\,HI\,(g)$ at 25 °C is $K_p = 0.345$ at 25 °C.

(a; 8 pts) If the partial pressure of H_2 is $P_{H2} = 1.00$ atm and solid iodine is present, what is the equilibrium partial pressure of HI at 25 °C?

(b; 9 pts) An excess of solid I_2 is added to a container initially filled with 4.00 atm of H_2 at 25 °C. Calculate the partial pressures of H_2 and HI reached at equilibrium.

Score for the page_____

(c; 4 pts) If the volume of the container is increased at constant temperature, which way will the equilibrium shift and why?

(d; 4 pts) Why might Hilary Clinton be excited about the prospect of a hydrogen economy? In other words, describe a geopolitical consequence of running the cars in the US on hydrogen.

Page	Score
1	/1
2	/30
3	/22
4	/23
5	/17
6	/8
Total	**/101**

Score for the page_____