CHEM 36
General Chemistry
EXAM #2

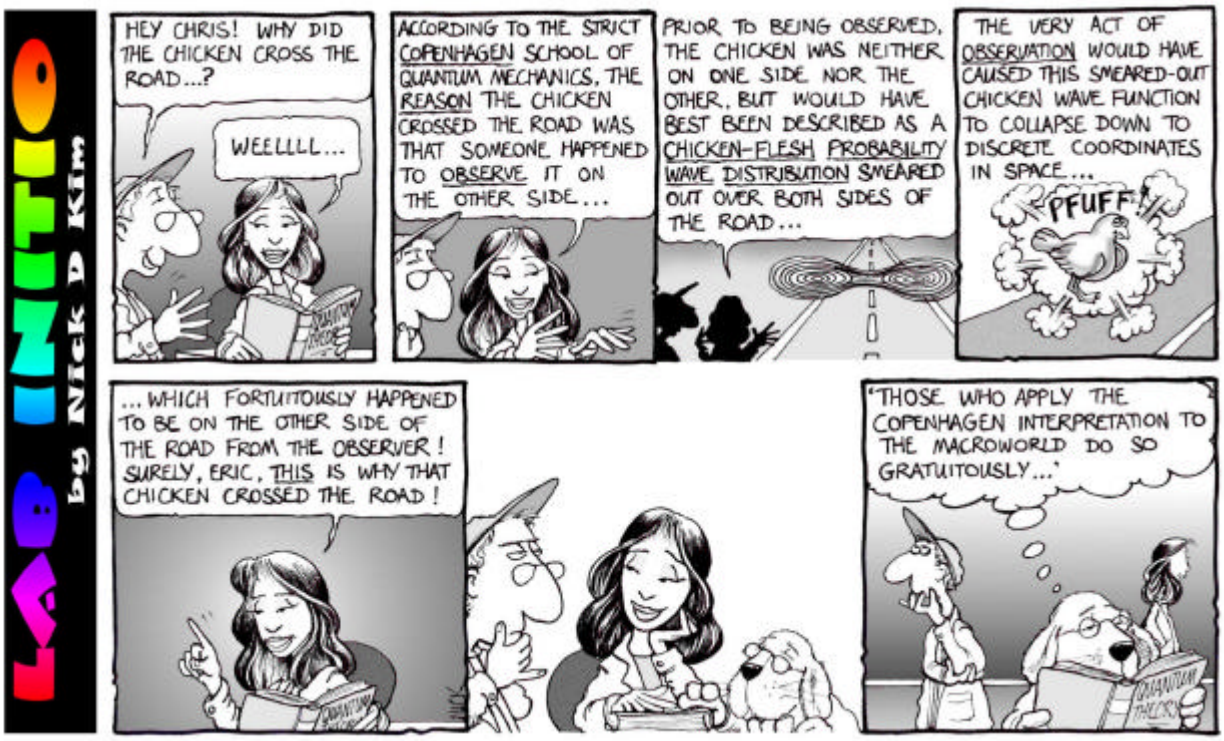
March 13, 2002

Name:_____

INSTRUCTIONS: Read through the entire exam before you begin. Answer all of the questions. For questions involving calculations, show **all** of your work -- **HOW** you arrived at a particular answer is **MORE** important than the answer itself! Circle your final answer to numerical questions.

The entire exam is worth a total of 150 points. Attached are a periodic table and a formula sheet jam-packed with useful stuff. Good Luck!

Page	Possible Points	*Points Earned*
2	25	
3	40	
4	25	
5	45	
6	25	
TOTAL:	***150***	



1. For the dissociation of acetic acid in water:

$$CH_3COOH\ (aq) \leftrightarrows H^+\ (aq) + CH_3COO^-\ (aq)$$

at 25.0°C, $K_a = 1.76 \times 10^{-5}$.

a. ***[10 pts]*** Calculate ΔG^o (kJ/mol) for this reaction.

b. ***[5 pts]*** At equilibrium, what is the value of ΔG?

2. ***[10 pts]*** Calculate the *molarity* of an aqueous acetic acid solution that is 36.0% acetic acid (by mass). The density of the solution is 1.045 g/mL and the molecular weight of acetic acid is 60.05 g/mol.

3. ***[15 pts]*** Given equilibrium constants for reactions 1 and 2, compute K_3:

(1) $H_2O\ (l) + H_2O(l) \leftrightarrows H_3O^+\ (aq) + OH^-\ (aq)$ $\quad K_1 = 1.0 \times 10^{-14}$

(2) $NH_4^+\ (aq) + H_2O\ (l) \leftrightarrows NH_3\ (aq) + H_3O^+\ (aq)$ $\quad K_2 = 5.7 \times 10^{-10}$

(3) $NH_3\ (aq) + H_2O\ (l) \leftrightarrows NH_4^+\ (aq) + OH^-\ (aq)$ $\quad K_3 = ???$

4. Chloroacetic acid dissociates in aqueous solution to produce the chloroacetate and hydronium ions:

$$CH_2ClCOOH\ (aq) + H_2O\ (l) \leftrightarrows CH_2ClCOO^-\ (aq) + H_3O^+\ (aq)$$

a. ***[10 pts]*** Compute K at 25.0 ^oC. given the following set of equilibrium concentrations:

$[CH_2ClCOOH] = 0.0888\ M$
$[CH_2ClCOO^-] = 0.0112\ M$
$[H_3O^+] = 0.0112\ M$

b. ***[5 pts]*** Calculate the pH of this solution.

5. Consider the following endothermic (ΔH^o = 41.18 kJ/mol) reaction:

$$CO_2\ (g) + H_2(g) \leftrightarrows CO\ (g) + H_2O\ (l)$$

At 25.0 ^oC, K = 3.2 x 10^{-4}.

If we start with 1.0 atm of each of the gas phase species in a closed vessel containing some water:

a. ***[10 pts]*** Is the system at equilibrium? If not, will the reaction proceed to the *left* or to the *right* in order to reach equilibrium?

Left ***Right*** ***No Change*** (circle one)

b. ***[15 pts]*** Calculate the partial pressure of H_2 (g) for the system at equilibrium.

c. ***[5 pts each]*** How will the equilibrium partial pressure of H_2 (g) be affected by the following:

i. CO_2 (g) is added to the system (at constant volume).

Increase ***Decrease*** ***No Change*** (circle one)

ii. The volume of the reaction vessel is halved.

Increase ***Decrease*** ***No Change*** (circle one)

iii. Argon gas is added to the system (at constant volume).

Increase ***Decrease*** ***No Change*** (circle one)

iv. The temperature of the system is increased.

Increase ***Decrease*** ***No Change*** (circle one)

6a. ***[10 pts]*** Arrange the following acids in order of increasing strength (briefly explain your reasoning):

CH_3CH_2OH, $HClO_4$, CH_3COOH, H_2O

b. ***[10 pts]*** Identify the corresponding conjugate bases for these acids:

Acid	Conjugate Base
CH_3CH_2OH	
$HClO_4$	
CH_3COOH	
H_3O^+	

c. ***[5 pts]*** Arrange the conjugate bases in order of increasing strength.

7. ***[5 pts each]*** Given the K_a values for the following acids:

$CH_2ClCOOH$ (Chloroacetic Acid): $K_a = 1.4 \times 10^{-3}$
C_6H_5COOH (Benzoic Acid) $K_a = 6.5 \times 10^{-5}$
HCN (Hydrocyanic Acid) $K_a = 6.2 \times 10^{-10}$

a. Which acid is the weakest?

b. Write the acid dissociation equilibrium reaction for the acid you identified in part a.

c. Which of the conjugate bases for these acids is the weakest?

d. Calculate the value of K_b for the base you identified in part c.

e. Write the base dissociation (K_b) equilibrium reaction for the base you identified in part c.

Extra Credit! -- 10 pts

The triple bond in the N_2 molecule is very strong, but at high enough temperatures even it breaks down. At 5000 K, when the total pressure exerted by a sample of nitrogen is 1.00 atm, N_2 (g) is 0.65% dissociated at equilibrium:

$$N_2 \text{ (g)} \leftrightarrows 2 \text{ N (g)}$$

At 6000 K, with the same total pressure, the proportion of N_2 (g) dissociated at equilibrium rises to 11.6%. Calculate the ΔH of this reaction.