CheM 1422 – Exam #3 (April 23, 2009)

Acids/Bases & Redox/Electrochemistry

Put a big X this box if you want your graded exam put out in the public racks outside Prof. Stanley’s office after grading. If you don’t check it, Prof. Stanley will keep your exam and you will have to stop by to pick it up from him personally.

1. (5 pts) Consider the following anions. Using fundamental concepts we have discussed in class, which one would be the weakest conjugate base and give rise to the strongest acid. Circle your choice and provide clear reasoning for your answer.
   a) AsO$_4^{3-}$
   b) F$^-$
   c) PH$_2^-$
   d) CO$_3^{2-}$
   e) PF$_6^-$

2. (5 pts) [N(CH$_3$)$_2$]$^-$ is a stronger base than OH$^-$. If 0.1 moles of [N(CH$_3$)$_2$]$^-$ is added to 1 L of water, what will the resulting pH be? Circle the answer (yes, the correct answer is there) and clearly explain your reasoning below.
   a) 0
   b) 0.1
   c) 7
   d) 13
   e) 25

3. (5 pts) Identify the following 1:1 solution mixtures as acidic, basic, or neutral.
   a) NH$_3$ + NH$_4$NO$_3$ (pK$_a$ = 9.3)
   b) NaBr + KClO$_4$
   c) H$_3$PO$_4$ + NaH$_2$PO$_4$ (pK$_a$ = 2.1)
   d) C$_5$H$_4$N (pyridine) + [C$_5$H$_4$NH]Br (pK$_a$ = 5.2)
   e) H$_2$S + CsHS (pK$_b$ = 7.0)

4. (5 pts) Calculate the pH of a 0.1 M solution of carbonic acid, H$_2$CO$_3$. pK$_{a1}$ = 7, pK$_{a2}$ = 11.
   Circle your choice and clearly show your work (or reasoning) below.
   a) –1
   b) 2
   c) 4
   d) 5
   e) 10
5. (5 pts) Which of the following salts will produce an acidic solution when dissolved in water? Circle your answer and briefly discuss your reasoning in the space below.

a) KClO₄  b) Cs₂S  c) Li₂CO₃  d) CrCl₃  e) Mg(OH)₂

6. (5 pts) What is the pH of a 1.0 M solution of sodium carbonate (Na₂CO₃).  pK₆(CO₃²⁻) = 4

Clearly show all your work. Put a box around your final answer.

7. (5 pts) Which of the following substances is the best reducing agent? Circle your answer and briefly explain your reasoning below.

a) Na⁺  b) Pb  c) Li⁺  d) F⁻  e) Mg

8. (5 pts) What is the potential of a battery composed of the following: Al/Al³⁺(aq, 1 M) and Ag/Ag⁺(aq, 1 M)? Temperature = 25°C. Clearly show all your work and the overall balanced reaction.

9. (5 pts) Given the data presented on the Standard Reduction Potential Table provided, what is the highest voltage single cell battery that you could make? Write the overall balanced rxn and potential. Briefly discuss why this “ultimate” battery isn’t practical.
10. (5 pts) Qualitatively how would the hydrogen electrode potential change if the $[H^+]$ concentration changed from 1.0 $M$? Why?

11. (10 pts) 100 mL of 0.5 M acetic acid (HOAc) reacts with 400 mL of 0.125 M NaOH. What is the pH of the resulting solution? $pK_a$ (HOAc) = 5  Clearly show all your work. Put a box around your final answer.

12. (10 pts) Consider the titration curve shown to the right.
   a) (2 pts) What type of material (acid or base) is being titrated? Brief reasoning?
   b) (2 pts) Is the material from part a) strong or weak? Brief reasoning?
   c) (2 pts) Why is the region between 10 & 20 mL not changing pH?
   d) (4 pts) What is the approximate $pK_{a/b}$ of the material in question? Brief reasoning?
13. (10 pts) Balance the following reaction in basic solution (add, CN\(^-\), water or OH\(^-\) as needed). Clearly show all your work.

\[
\text{Au}(s) + \text{CN}^- (aq) + \text{O}_2 (g) \rightarrow [\text{Au(CN)}_4]^- (aq) + \text{OH}^- (aq)
\]

14. (10 pts) How many moles of Al can be deposited per hour from a molten mass of Al\(_2\)O\(_3\)/Na\(_3\)AlF\(_6\) if a current of 30,000 amps is used?

15. (10 pts) Consider the following electrochemical cell at 25°C: H\(_2\)(g)/2H\(^+\)(aq) and Ag/Ag\(^+\)(aq, 1.0 M). A potential of 0.741 V is measured. What is the pH of the cell? Clearly show all your work.