Chemistry 301 - FINAL EXAM

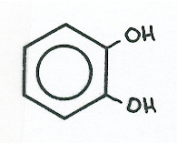
Tuesday, December 16, 2008, 12:00 pm

Only the standard UBC Science calculator (Sharp 510B) is permitted.
Show your work and explain your answers whenever possible.

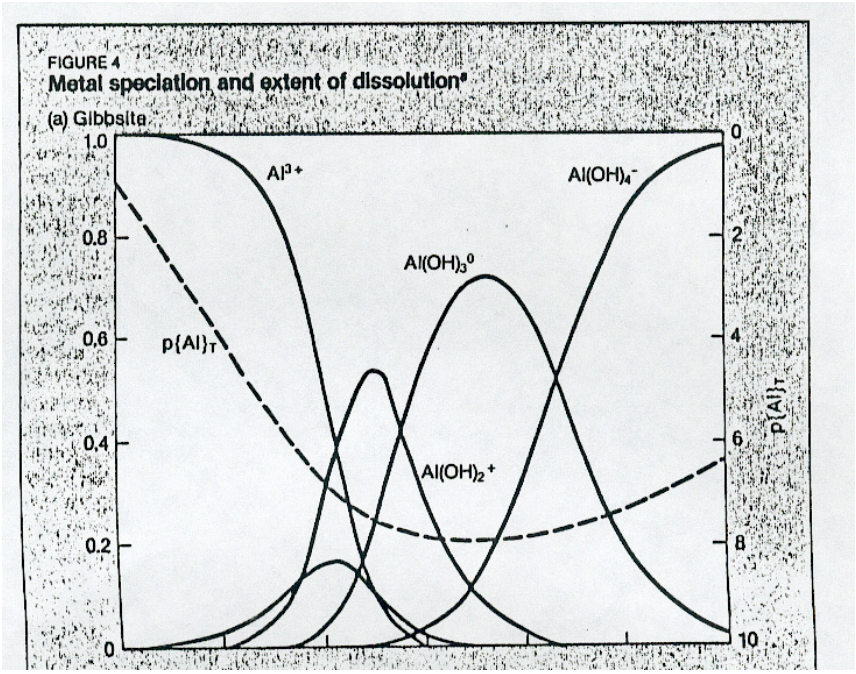
55 points total (55% of total marks for course)

1. (6 pts) Explain the concept of alkalinity using words. Do you expect the water here in Vancouver to be relatively high or low in alkalinity? Why? What is the equation for carbonate alkalinity? Does CO_2 contribute to alkalinity? If so, how?

2. (3 points) What is a chelate? Which of the following are a good chelators? Why?
   a) phosphate
   b) pyrophosphate
   c) NTA
   d) nitrate
   e) "catechol" →



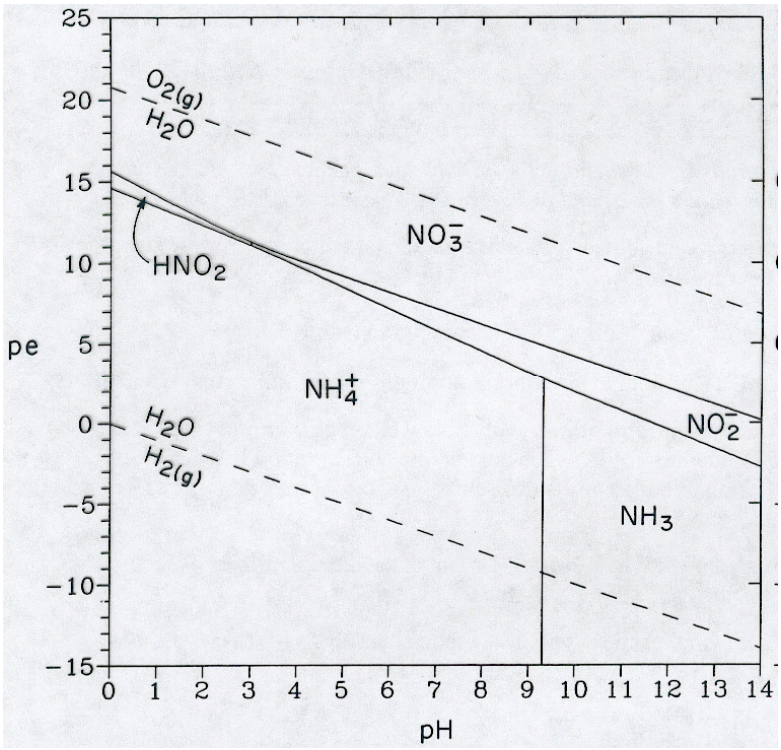
3. (5 pts) What is "filter alum", and why might it be used in water treatment? How does it work? Using the distribution diagram below (fraction of total for each species as a function of pH), determine the pH range over which filter alum is effective – and explain how you determined this from the diagram.



4. (5 points) Calculate the partial pressure of O_2 in acid mine water with a pH of 2.0 in which $[Fe^{+2}] = [Fe^{+3}]$? (you may round off all constants if you are not using a calculator)

5. (6 points) "A high pε indicates an oxidizing environment, while a high $p\varepsilon^o$ indicates a reaction that is likely to go to reduced products". Is this statement true? If so, is it a contradiction? Explain your logic, and include a definition of pε, $p\varepsilon^o$, "oxidizing environment" and "reduced products" as part of your answer.

6. (6 pts) Given the pε-pH diagram for N species shown below, and what you know about the nitrogen cycle, answer the following questions:



a) (1pt) What is the most oxidized form of N found in the environment?
b) (1pt) What form of N do you expect to dominate in anoxic environment at pH 7?
c) (2pts) What are the processes called for the conversion between these two forms (both directions)?
d) (2pts) Under what conditions do you expect these conversions to occur? Are microorganisms important in these conversions? If so, how?

7. (6 pts) Describe (with words) why mining results in acid mine drainage (AMD). What are the two biggest problems associated with AMD? Describe one method for the passive treatment of AMD and describe how it addresses both of these problems.

8. (5 pts) You are given the job of estimating the amount (per litre) of chlorine to add to the drinking water for a small town. You do a bit of research, and discover the amount (per litre) that a nearby city has determined to be optimal. They also have made available to you a long list of test results from their water. You have a small budget, and can only run 2 tests on your water to determine if the same level of chlorine is also optimal for your town, or whether you should recommend a higher or lower dose. What tests do you choose to run? Why? What difference do these parameters make? Under what circumstances would you recommend a higher or lower dose?

9. (5 points) A lead recycling plant begins operation on the shores of a formerly clean lake of capacity 5.0×10^6 m^3. It discharges into the lake 10 m^3 per hour of waste containing 10 micromolar Pb^{2+} (10×10^{-6} M). The other inflow to the lake is a river with a flow rate of 5000 m^3/hr.

   a) (1pt) What is the residence time of the water in this lake?

   b) Calculate the steady state concentration of Pb^{2+} in the lake, which is well mixed, and has no other sources or sinks for Pb^{2+}.

   c) (2 pts) If the pH of this lake, after the new steady state is attained, is 8.0, do you expect the added lead to form an insoluble hydroxide precipitate? Does this affect your estimate of the concentration of Pb^{2+} in the lake (from part b above)? If so, what is your new estimate for the concentration of Pb^{2+} in the lake?

10. (3 pts) A water quality inspector discovers that the water in a region is high in radium ($^{226}_{88}Ra$). What is the likely source of this radionuclide? What can be done to fix this problem? If $^{226}_{88}Ra$ decays by alpha decay, what is its daughter?

11. (5 pts) What are the typical sources, transformations and problems associated with excessive nutrients in the environment?