

Chemistry 301 - MIDTERM EXAM #2**Wednesday, November 7, 2012, 9:00 am***Only the standard UBC Science calculator (Sharp 510B) is permitted.*

Worth 28 points (20% of course)

PART I (multiple choice – 13 points)*One point for each correct answer. No penalty for wrong answers - if you don't know, then guess. There is only one best answer for each question.*

1. If the CEC value of a sediment sample is determined to be 37meq/100g, with the following metals measured to have been associated with the sediment: $[\text{Al}^{3+}] = 4$ mmol/100g, $[\text{Ca}^{2+}] = 3$ mmol/100g, and $[\text{Na}^+] = 10$ mmol/100g. No other metal ions appear to be present, what is the ECS of H^+ for the sample?
a) 9 meq/100g
b) 12 meq/100g
c) 13 meq/100g
d) 20 meq/100g
e) 54 meq/100g
f) cannot be determined from the information given
2. What are the three primary methods by which sediments are formed?
a) weathering, iron reduction reactions, biological processes
b) clay formation, precipitation reactions, iron reduction reactions
c) weathering, biological processes, precipitation reactions
d) clay formation, pore water formation, organic matter accumulation
e) oxidation-reduction reactions, organic matter accumulation, precipitation reactions
3. What is the ratio of Hg^{2+} to Cd^{2+} at equilibrium in an electrochemical cell in otherwise pure water, when in contact with Hg^0 and Cd^0 ?
a) $10^{-40.32}$
b) $10^{-20.16}$
c) $10^{-13.08}$
d) $10^{-6.54}$
e) $10^{-13.35}$
4. What is nitrogen fixation?
a) the conversion of ammonium to nitrite
b) the removal of H^+ from nitrogen species to assimilate it
c) the conversion of nitrate to organic nitrogen
d) the conversion of organic nitrogen into ammonium
e) the conversion of gaseous nitrogen into organic nitrogen
f) the conversation of nitrite to nitrate

5. In the clay $(\text{Na}^+n\text{H}_2\text{O})(\text{Mg}_{3-x}\text{Na}^+)(\text{Si}_4)(\text{OH})_2\text{O}_{10}$, where is the charge generated?
 - a) in the Si layer
 - b) in the Na^+ layer
 - c) In the OH^- layer
 - d) In the Mg layer**

6. On a $\text{p}\epsilon$ -pH diagram, what does the line that transitions between Fe^{2+} and Fe^{3+} look like?
 - a) vertical
 - b) horizontal**
 - c) sloped downward
 - d) sloped upward
 - e) the line is not within the region typically shown on $\text{p}\epsilon$ -pH diagrams

7. When the $\text{p}\epsilon$ is greater than the 13.2, for the $\text{Fe}^{2+}/\text{Fe}^{3+}$ redox couple you expect:
 - a) Only Fe^{2+} to be present
 - b) Only Fe^{3+} to be present
 - c) Both Fe^{2+} and Fe^{3+} present in equal amounts
 - d) Both Fe^{2+} and Fe^{3+} present, but more Fe^{2+} than Fe^{3+}
 - e) Both Fe^{2+} and Fe^{3+} present, but more Fe^{3+} than Fe^{2+}**

8. Why are polyelectrolytes sometimes added during water treatment?
 - a) to remove metals dredged from harbors
 - b) to remove BOD**
 - c) to increase phytoplankton growth
 - d) to remove CO_2
 - e) to lower the ionic strength

9. Which of the following changes can cause a conversion from Fe^{2+} to $\text{Fe}(\text{OH})_3$?
 - a) Only an increase in pH
 - b) Only a decrease in pH
 - c) Only an increase in $\text{p}\epsilon$
 - d) Only a decrease in $\text{p}\epsilon$
 - e) Either an increase in pH or an increase in $\text{p}\epsilon$**
 - f) Either an increase in pH or a decrease in $\text{p}\epsilon$
 - g) Either a decrease in pH or an increase in $\text{p}\epsilon$
 - h) Either a decrease in pH or a decrease in $\text{p}\epsilon$

10. Which type of reactions require a value for maximum soluble metals to be set on a $\text{p}\epsilon$ -pH diagram?
 - a) electron transfer
 - b) proton transfer
 - c) precipitation reaction**
 - d) reduction reaction
 - e) hydroxide transfer

11. Why is dredging harbours potentially harmful to the environment?
- a) reduced species at the bottom of a harbour are more toxic than oxidized species at the surface
 - b) the area becomes anoxic from all of the reduced species reacting with oxygen
 - c) toxic metals are released into the water due to oxidation reactions**
 - d) sediments contain sulfide, which is poisonous if brought to the surface
 - e) colloids are brought to the surface and disrupt biological processes
12. How does making anaerobic wetlands help treat acid mine drainage?
- a) It causes $\text{Fe}(\text{OH})_3$ to form
 - b) It causes peat to be more reactive
 - c) It helps remove yellowboy from the area
 - d) It causes FeS_2 to form**
 - e) It causes methanogenesis, which increases the pH of the system
13. Why does the size of an individual colloid matter for metal interactions?
- a) it affects how quickly they move through the water
 - b) it determines the charge
 - c) it changes how quickly colloids aggregate together
 - d) it determines the surface area to volume ratio**
 - e) it affects the weight of the particle

PART II (short answer – 15 pts)

14. 3 pts) How does anaerobic respiration affect BOD? Define all terms used in your answer.

Anaerobic respiration is the degradation (oxidation) of organic matter using alternate oxidant (SO_4^{2-} or CO_2)

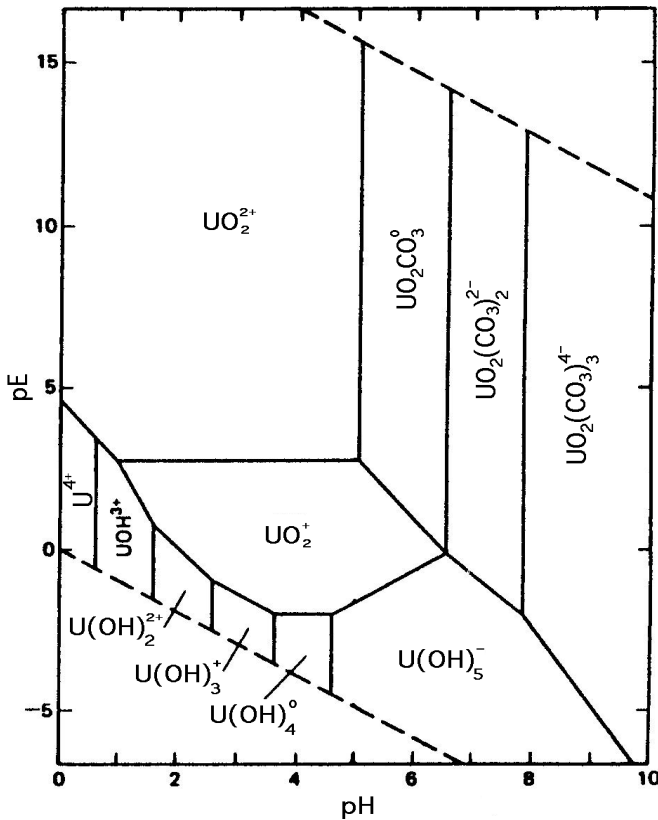
BOD is biological oxygen demand, which is the total amount of reduced substances that can consume O_2 . It is mostly due to organic matter.

Anaerobic respiration removes organic matter without consuming oxygen, which decreases biological oxygen demand.

15. (3 pts) In the aerobic treatment of ARD, often $\text{Ca}(\text{OH})_2$ (lime) and/or CaCO_3 are used to treat the acid. What happens to the metals under these conditions?

Higher pH leads to higher hydroxo and oxo species, so metal hydroxides form, which are often less soluble than the hydrated (aqua) forms that exist at low pH. The precipitation of metal hydroxides is what will happen to the metals.

16. (5 pts) Given the pe-pH diagram for uranium below, answer the questions that follow.



a) (1 pt) To create the pe-pH diagram above, how many independent equations are needed? Why?

11 equations are needed - the same number as the species being considered (13 was accepted with an explanation of use of H_2 and O_2 as extra lines.)

b) (2 pts) How many different oxidation states are important for U according to this diagram? What are they?

There are three oxidation states -

- **+6 for UO_2^{2+} and its carbonate complexes**
- **+5 for UO_2^+**
- **+4 for U^{4+} and its OH^- complexes**

c) (1 pt) What form of uranium do you expect to find in anoxic marine waters (controlled by the sulphate/sulphide redox couple)?



d) (1 pt) What form of uranium do you expect to find in acid mine waters?



Name _____

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17. (4 pts) In the oxidation of organic matter, there are several potential oxidants that can be used:

a) (0.5 pt) What determines the sequence of the oxidants used?

The free energy yield. (The strongest oxidant yields more energy per unit of organic matter and is used first.)

b) (1.5 pt) What are the three oxidants that tend to be most relevant in the aquatic environment?

O₂, SO₄²⁻, CO₂

c) (2 pt) Which oxidants are more important in the sediments than in water? Why?

MnO₂ and FeOOH. These species are solid in their oxidized forms, so they are not very abundant in water.

Extra space