

Mid-Term Exam

October 28, 2010

Closed Book, one sheet of notes allowed

Please answer any 4 of the following 9 questions on separate sheets of paper (except for the T/F questions that may be answered directly on this paper. Each is worth 25 points. Indicate which 4 you'd like me to grade in the box at right.

Show all work. Be neat, and box-in your answer. Hand in your answer pages and the exam handout together.

Please grade the following questions:

1	2	3
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4	5	6
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7	8	9
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Circle four only

- 1. A tanker of hydrochloric acid overturns on Rte 128. A Hazmat team springs into action ready to neutralize the spill with a tanker of 50% (by weight) NaOH solution. If the overturned tanker spills 400 gallons of 12 M hydrochloric acid, how many gallons of the 50% NaOH is needed to exactly neutralize it?**

Note that a 50% NaOH solution has a specific gravity of 1.53, meaning that 1 liter of this solution weights 1.53 kg.

- 2. Calculate the ThOD of the following solutions in mg/L and indicate which family of organic compounds each comes from:**

- 10^{-3} moles/L of hexane, C_6H_{14}
- 3×10^{-3} moles/L of oxalic acid, $C_2H_2O_4$
- 30 mg/L of ethanol, CH_3CH_2OH

3. You're checking on the suitability of an urban groundwater as a drinking water source. You request a complete analysis of major inorganic ions from a commercial laboratory and the results are shown below.

Chemical Substance	Conc. (mg/L)
Na ⁺	31.1
K ⁺	7.7
Ca ⁺²	21.2
Mg ⁺²	3.5
NO ₃ ⁻	2.1
SO ₄ ⁻²	5.6
Br ⁻	0.5
HCO ₃ ⁻	87.9

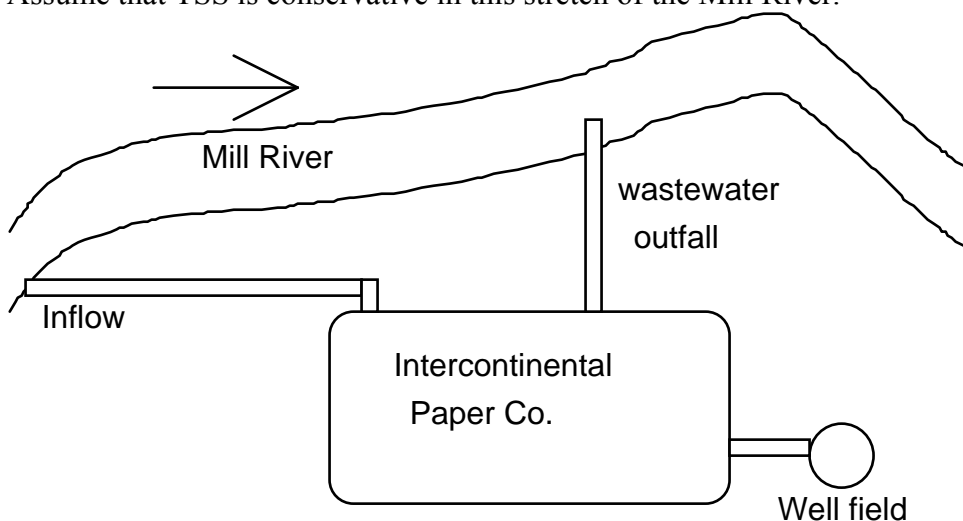
- A. Check the results by performing a charge balance. What is the percent difference between the anions and cations?**
- B. The lab also measured 117 mg/L total dissolved solids. What value would you expect based on the data in the table above?**
- C. Do these results seem to be complete and accurate based on your answers in A and B? Explain.**

4. You're examining a 1st order batch reaction that occurs with a half-life of 90 minutes.

- A. What is the value of the reaction rate constant in units of min⁻¹?**
- B. How long will it take to reach 99% removal?**
- C. What would the fraction remaining be if you were doing this in a CMFR with a retention time of 5 hours**

5. Intercontinental Paper and the Mill River

The Intercontinental Paper Co. is discharging its wastewater directly into the Mill River. The discharge flow is $3.8 \text{ ft}^3/\text{s}$ (cfs). They obtain half of this water from an intake 0.5 miles upstream of the wastewater outfall, and half from groundwater via a nearby well field. On average, the Mill River water upstream of IPC has a total suspended solids concentration (TSS) of 2.5 mg/L . If the Mill River has a flow of 12 cfs upstream of the IPC intake, and if the state permits a maximum TSS concentration of 15 mg/L in the Mill River, what will the allowable effluent concentration of suspended solids be for IPC? Assume that TSS is conservative in this stretch of the Mill River.



6. Indicate whether the following statements are true (T) or false (F).

1.	<input type="checkbox"/>	Prokaryotic organisms include all higher plants and animals
2.	<input type="checkbox"/>	A triprotic acid has three times the strength as a monoprotic acid
3.	<input type="checkbox"/>	A conjugate base is what forms when an acid loses a proton
4.	<input type="checkbox"/>	When an organic compound name ends in "al", it usually means the compound is an alcohol
5.	<input type="checkbox"/>	Proteins are composed mostly of amino acids
6.	<input type="checkbox"/>	When Gibbs Free Energy increases, the reaction will tend to go forward
7.	<input type="checkbox"/>	Ethers have carbon-nitrogen bonds
8.	<input type="checkbox"/>	Henry's law describes the relationship between partial pressure and dissolved concentration
9.	<input type="checkbox"/>	Autotrophs can use inorganic carbon for cell synthesis
10.	<input type="checkbox"/>	Changes in ionic strength can cause shifts in chemical equilibria
11.	<input type="checkbox"/>	An element of high electronegativity will share its bonding electrons equally with an element of low electronegativity
12.	<input type="checkbox"/>	Cryptosporidium is a type of prion

7. The equilibrium constant for the following reaction is $10^{-6.3}$. What percent of the total carbonate is in the form of bicarbonate at pH 5.5?



8. A rapidly growing suburb has a population of 11,500 in 2000 and 16,300 in 2010.

- A. Predict the 2030 population assuming an exponential growth model.
- B. Make a second prediction for 2030, but this time presume that the housing availability will limit the maximum population to 30,000. Assume the population approaches this limit at a rate of 0.1 yr^{-1} .

9. An urban area receives 48 inches of rain per year. Using the rational formula, calculate the average runoff for this area in cubic feet per second (cfs).

Assume it encompasses 20,000 acres, including 3000 acres of urban business land, 6000 acres of urban single family housing land, 6000 acres of multi-family housing, 3000 acres of land occupied by apartments and 2000 acres of parks and cemeteries.

Area Description	average runoff coefficient
Urban Business	0.8
Urban single family	0.4
multifamily homes	0.5
Apartments	0.6
Parks & Cemeteries	0.15

Appendix

Selected Chemical Constants

Element	Symbol	Atomic #	Atomic Wt.	Valence	Electronegativity
Aluminum	Al	13	26.98	3	1.47
Boron	B	5	10.81	3	2.01
Bromine	Br	35	79.9	1,2,5,7	large
Calcium	Ca	20	40.08	2	1.04
Carbon	C	6	12.01	2,4	2.50
Chlorine	Cl	17	35.453	1,3,5,7	2.83
Chromium	Cr	24	52.00	many	1.56
Helium	He	2	4.00	0	
Holmium	Ho	67	164.93	3	1.10
Hydrogen	H	1	1.01	1	2.20
Magnesium	Mg	12	24.31	2	1.23
Manganese	Mn	25	54.94	2,3,4,6,7	1.60
Nitrogen	N	7	14.01	many	3.07
Oxygen	O	8	16.00	2	3.50
Potassium	K	19	39.10	1	0.91
Sodium	Na	11	22.99	1	1.01
Sulfur	S	16	32.06	2,4,6	2.44

Selected Acidity Constants (Aqueous Solution, 25°C, I = 0)

NAME	FORMULA	pK _a
Hydrochloric acid	$\text{HCl} = \text{H}^+ + \text{Cl}^-$	-3
Sulfuric acid	$\text{H}_2\text{SO}_4 = \text{H}^+ + \text{HSO}_4^-$	-3
Nitric acid	$\text{HNO}_3 = \text{H}^+ + \text{NO}_3^-$	-0
Bisulfate ion	$\text{HSO}_4^- = \text{H}^+ + \text{SO}_4^{2-}$	2
Phosphoric acid	$\text{H}_3\text{PO}_4 = \text{H}^+ + \text{H}_2\text{PO}_4^-$	2.15
Hydrofluoric acid	$\text{HF} = \text{H}^+ + \text{F}^-$	3.2
Nitrous acid	$\text{HNO}_2 = \text{H}^+ + \text{NO}_2^-$	4.5
Acetic acid	$\text{CH}_3\text{COOH} = \text{H}^+ + \text{CH}_3\text{COO}^-$	4.75
Propionic acid	$\text{C}_2\text{H}_5\text{COOH} = \text{H}^+ + \text{C}_2\text{H}_5\text{COO}^-$	4.87
Carbonic acid	$\text{H}_2\text{CO}_3 = \text{H}^+ + \text{HCO}_3^-$	6.35
Hydrogen sulfide	$\text{H}_2\text{S} = \text{H}^+ + \text{HS}^-$	7.02
Dihydrogen phosphate	$\text{H}_2\text{PO}_4^- = \text{H}^+ + \text{HPO}_4^{2-}$	7.2
Hypochlorous acid	$\text{HOCl} = \text{H}^+ + \text{OCl}^-$	7.5
Ammonium ion	$\text{NH}_4^+ = \text{H}^+ + \text{NH}_3$	9.24
Hydrocyanic acid	$\text{HCN} = \text{H}^+ + \text{CN}^-$	9.3
Phenol	$\text{C}_6\text{H}_5\text{OH} = \text{H}^+ + \text{C}_6\text{H}_5\text{O}^-$	9.9
Bicarbonate ion	$\text{HCO}_3^- = \text{H}^+ + \text{CO}_3^{2-}$	10.33
Monohydrogen phosphate	$\text{HPO}_4^{2-} = \text{H}^+ + \text{PO}_4^{3-}$	12.3
Bisulfide ion	$\text{HS}^- = \text{H}^+ + \text{S}^{2-}$	13.9

Conversions

7.48 gallon = 1.0 ft³ 1 gal = 3.7854x10⁻³ m³

1 MGD = 694 gal/min = 1.547 ft³/s = 43.8 L/s

1 ft³/s = 449 gal/min

1 acre = 43,560 ft²

g = 32 ft/s²

W=γ = 62.4 lb/ft³ = 9.8 N/L

1 hp = 550 ft-lbs/s = 0.75 kW

1 mile = 5280 feet 1 ft = 0.3048 m

1 watt = 1 N-m/s

1 psi pressure = 2.3 vertical feet of water (head)

At 60 °F, ν = 1.217 x 10⁻⁵ ft²/s