Uva Wellassa University of Sri Lanka
Faculty of Science and Technology
Department of Science and Technology
400 Level 1st Semester Examination – June/July 2017

MRT 422-3 Advanced Water Chemistry

Part II: Answer in separate answer book provided

1.

(a) Define buffer capacity of a water sample. Show that the buffer capacity value can never be zero at ambient environmental conditions.

(b) Write an expression to calculate alkalinity in water with following chemical composition: Na^+, K^+, Mg^{2+}, Ca^{2+}, CO^{2-}_3, HCO^-_3, SO_4^{2-}, Cl^- and NO_3^-.

(i) Which species contributes to water alkalinity?

(ii) If you bubbled the water sample with carbon dioxide, what happens to the alkalinity against $CO_{2(gas)}$? Will it decrease, increase or has no effect on CO_2 addition on alkalinity?

(c) Calculate [Alk] of following solutions.

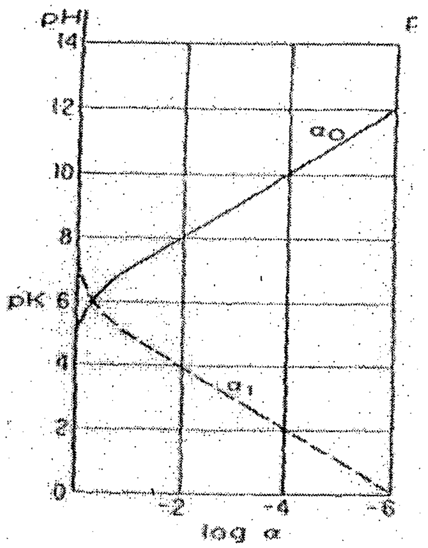
(i) Pure water
(iv) 10^{-5} M NaOH, 10^{-4}M HCl
(vi) 10^{-3}M $NaHCO_3$, 10^{-3}M HCl

(d) Assume that aqueous solutions do not change in volume significantly when the temperature and/or pressure are changed over narrow intervals. Comment on alkalinity variations as a function of T and P.

2.

(a) Consider a calcite solution in contact with a gas phase with a fixed pCO_2. Show that $a^3_{H+} = \frac{p^2_{CO2}K^2_1K^2_{CO2}K_2}{2K_{calcite}}$

(b) A chemical speciation diagram is shown below.



Draw the titration curve showing HA and NaA equivalent points. Justify your answer using relevant charge and mass balance equations.

(c) Prove that $[H_2CO_3] = \frac{C_T}{1+\frac{K_1}{[H^+]}+\frac{K_1K_2}{[H^+]^2}}$ for a closed CO_2-H_2O system.

(d) When $pH < pK_1 < pK_2$ deduce a simplified expression for the estimation $[H_2CO_3]$.

3.

Part A

A water sample contains Fe^{2+} $10^{-4.95}$ and Fe^{3+} $10^{-2.29}$ M with a pH = 3.5 at 25 ^{0}C?
(Nernst equation: $Eh = E^0 + \frac{RT}{nF} ln\left(\frac{D_{Ox}^d}{B_{red}^b}\right)$; $E^0\ (Fe) = 0.77\ V\ and\ E^0\ (Mn) = 0.23V$; R=8.314J/K/mol; F = 96500 C/mol)

(a) Calculate the Eh of Fe^{2+}/Fe^{3+} redox couple.

(b) What would be $[Mn^{2+}]$ if this water were equilibrated with sediments containing MnO_2?

Part B

(c) Explain redox buffer capacity of natural water systems.

(d) What are terminal electron acceptors? How do they operate in natural waters?

4.

(a) With the aid of a labeled diagram explain the development of electrical double layer at gibbsite – solution interface.

(b) Giving examples differentiate inner and outer sphere surface complexes.

(c) Explain the removal mechanism of water hardness by ion exchange resins.

(d) A water sample contains turbidity. Describe a treatment technique to be used for its removal.

5.

Sorption of P by $Fe(OH)_3$ was measured at pH 7 and 298 K. In the experiment, 51.3 mg of a $Fe(OH)_3$ (weight as Fe) were suspended in 50 ml of a 0.01 M KCl. The data are shown below.

P added, mg/L	P at equilibrium in solution, µg/L
2.00	0.84
4.00	1.68
6.00	2.52
10.00	4.20
16.00	6.72
20.00	8.40

(a) State linearized Langmuir and Freundlich equations.

(b) Test to see if the data obey a Freundlich isotherm, solving for the constant in the model. Is the Freundlich model is appropriate to be used in this case? Explain.

(c) Test to see if the data obey a Langmuir isotherm, solving for the constants in the model. Is the Langmuir model is appropriate to be used in this case? Explain.

(d) What are the limitations of sorption of P using the isotherm equations?