Uva Wellassa University, Sri Lanka
End Semester Examination – February/March 2012
MRT 321-3: Water Chemistry

Uva Wellassa University

Duration: Three (03) hours

Total six (06) questions
Answer all questions
All symbols carry standard meanings
Use of standard symbols without a definition is allowed

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1. (a) **(25 marks)** Following activity models are given:

$$\log\gamma_i = \frac{-Az_i^2\sqrt{I}}{1+Ba_o\sqrt{I}} \qquad \log\gamma_i = -Az_i^2\left(\frac{\sqrt{I}}{1+\sqrt{I}} - 0.2I\right)$$

Identify Davis activity correction model. Define all terms therein.

(b) **(25 marks)** A water analysis gave following results;

Ca^{2+}	=	3.25 mM
Na^{+}	=	0.96 mM
HCO_3^{-}	=	5.75 mM
SO_4^{2-}	=	0.89 mM

What is the activity coefficient for Na^+?
(A = 0.55, B=0.33 x 10^{-8}; a_0 = 4 x 10^{-8}Å (for sodium ion)

(c) **(25 marks)** Calculate the activity of Na^+.

(d) **(25 marks)** In order to calculate the activity of Ca^{2+}, what additional parameter/s are needed?

2. (a) **(20 marks)** Define symmetric vs. asymmetric electrolytes.

(b) **(30 marks)** A routine analysis of a water sample provides the following concentrations (in mg L^{-1}): Ca, 93.9; Mg, 22.9; Na, 19.1; bicarbonate, 344; sulfate, 85.0; chloride, 9.0; pH: 7.20.

Express each concentration in terms of epm. What is the charge balance error? What is the ionic strength of the water sample?

(c) **(20 marks)** Determine the hardness of the water in mg L^{-1} as $CaCO_3$

(d) **(30 marks)** For the water sample in above (b), determine the saturation index for calcite at 25 °C given that $a_{CO_3^{2-}} = 0.34\times10^{-5}$ and that the equilibrium constant for calcite dissolution is 4.27×10^{-9}. What does the saturation index indicate about the state of saturation with respect to calcite?
Hint: $\gamma_{Ca^{2+}} = 0.650$
(Na 22.98; Ca 40.07; Mg 24.30; O 15.99; C 12.01; H 1.00; S 32.06; Cl 35.45)

3. (a) **(20 marks)** Define following terms.

(i). Alkalinity (ii) Buffer capacity

(b) **(20 marks)** Draw the pC - pH diagram of distilled water. Derive any equations used.

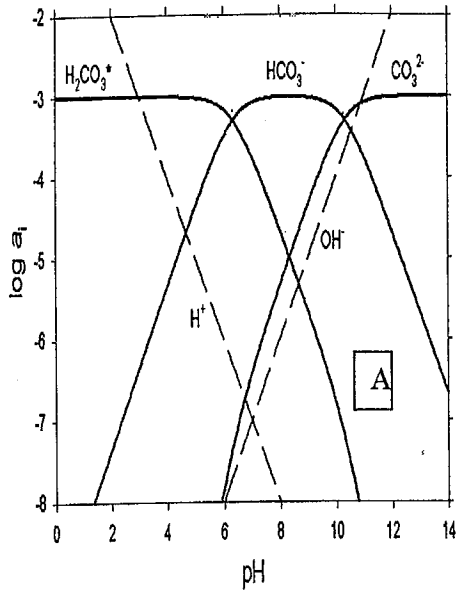
(c) **(20 marks)** Prove that the buffer capacity of any aqueous solution cannot be zero.

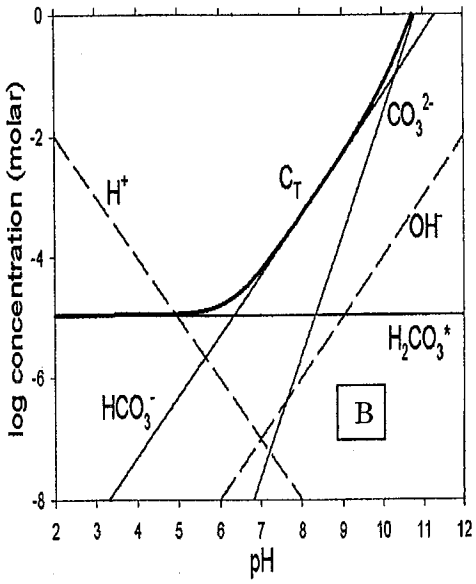
(d) **(40 marks)** Calculate the alkalinity of solutions with following composition:

(i) 0.001M Na_2CO_3 (ii) 0.01M NaCl + 0.01 M $MgCO_3$

4. (a) **(60 marks)** Differentiate open vs. closed systems with respect to $CO_2 - H_2O$ equilibrium.

(b) **(40 marks)** Use the diagrams shown below to answer questions:





(i) Define initial conditions of each diagram.

(ii) State all chemical equations used to plot these diagrams

(iii) Deduce the intrinsic acidity constants of carbonic acid with the help of these diagrams.

(iv) Deduce the pH of distilled water sample opened to atmospheric conditions with the help of the relevant diagram. Show all calculation steps.

5. (a) **(25 marks)** Define Eh of a given solution. Can it be measured experimentally?

(b) **(25 marks)** The natural limits of redox in natural waters are shown below. Derive the equations that correspond to upper and lower limits.

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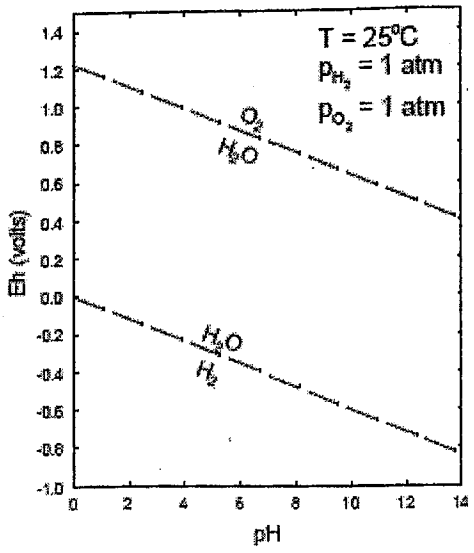

(c) **(25 marks)** Calculate the oxidation number of the elements shown in the following compounds

i. FeS_2 ii. FeAsS

(d) **(25 marks)** Write down half reactions of following processes:

(i). Oxidation of FeAsS

(ii) Reduction of CCl_4 by H_2

6. (a) **(20 marks)** Define following terms:

i. Adsorption ii. Absorption iii. Precipitation iv. Sorption

(b) **(20 marks)** Briefly state the mechanism of surface hydroxylation using $Al(OH)_3$ as an example.

(c) **(30 marks)** Derive a mathematical expression describing Langmuir isotherm. Clearly indicate all assumptions you make.

(d) **(30 marks)** State clearly the monolayer region of the Langmuir isotherm.