UNIVERSITY OF MINES AND TECHNOLOGY, TARKWA

SECOND SEMESTER EXAMINATIONS, MAY 2018

COURSE NO: GL 376

COURSE NAME: GROUNDWATER GEOCHEMISTRY

CLASS: **GL III** TIME:3hrs

Name**:** _____Index Number: _____

Answer Questions 1 - 3 and choose any other two from Questions 4-7

1. Given the following groundwater analysis at 25 ^{o}C (all values in mg/L):
Ca^{2+} 134, Na^{+} 145, Mg^{2+} 44, SO_4^{2-} 429, Cl^{-} 34, HCO_3^{-} 412, TDS 1205, pH 8.0
Make a trilinear plot, schoeller diagram and a stiff pattern of the analysis. Name the water type and give an interpretation for the type of groundwater. ***(20 marks)***

2. Determine whether the sample of groundwater is saturated with respect to calcite and anhydrite. ***(20 marks)***

3. Calculate the solubility product for barite $BaSO_4$ in hot springs with a temperature of 43 ^{o}C? ***(10 marks)***

4. What is geochemical equilibrium modelling and how can it be applied to solve current environmental problems. Give five examples to substantiate your arguments. ***(10 marks)***

5. Discuss five major factors that controls the overall quality of water. ***(10 marks)***

6. Using five cations and anions, describe the sources of different ions, the natural processes they undergo and processes that may limit their concentration ions in fresh water. ***(10 marks)***

7. Two major factors pH and pe influences the mobility of trace elements from/to the aqueous phase. Discuss with some specific examples. ***(10 marks)***

Dr A. Asante-Annor/Dr A. Ewusi

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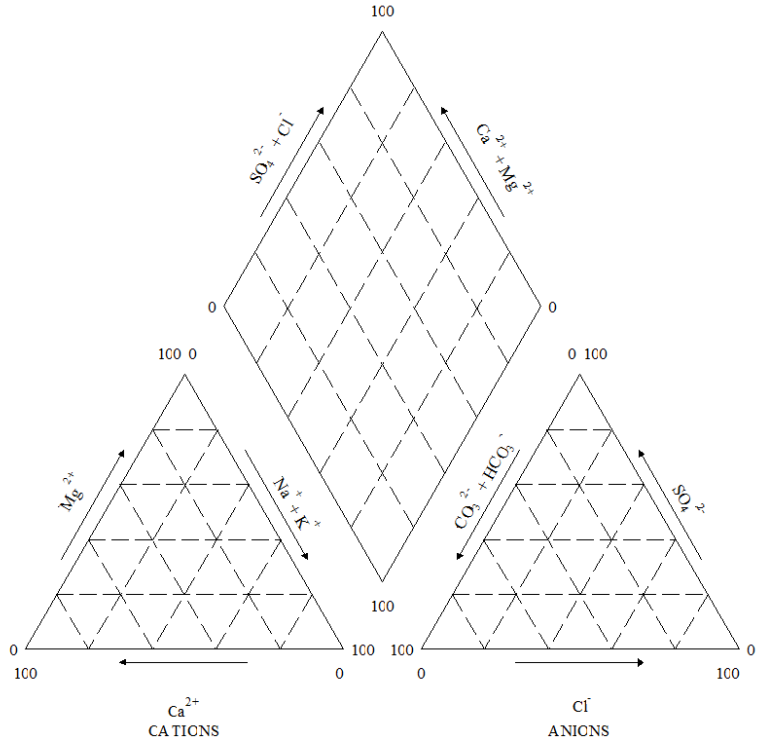
100
$SO_4^{2-} + Cl^-$
$Ca^{2+} + Mg^{2+}$
0
0
100 0
0 100
Mg^{2+}
$Na^+ + K^+$
$CO_3^{2-} + HCO_3^-$
SO_4^{2-}
100
0
100
100
0
100
0
100
Ca^{2+}
CATIONS
Cl^-
ANIONS

Table 1. Atomic/molecular weight

Species	Atomic or molecular weight	Valency
Na^+	22.991	1
K^+	39.102	1
Li^+	6.939	1
Ca^{2+}	40.08	2
Mg^{2+}	24.312	2
Sr^{2+}	87.62	2
Ba^{2+}	137.34	2
Fe^{2+}	55.847	2
Cl^-	35.453	−1
F^-	18.998	−1
Br^-	79.909	−1
NO_3^-	62.004	−1
SO_4^{2-}	96.06	−2
HCO_3^-	61.016	−1
CO_3^{2-}	60.008	−2
SiO_2	60.09	0
B	10.811	0
N	14.007	
O	15.999	
H_2O	18.015	
$CaCO_3$	100.088	

Table 2. For a_o - common ions for Debye Huckel equation

$a_o * 10^{-8}$	Ions
9	Al^{3+}, Fe^{3+}, H^+
8	Mg^{2+}
6	Ca^{2+}, Mn^{2+}, Fe^{2+}, Li^+
5	Sr^{2+}, Ba^{2+}, S^{2-}, CO_3^{2-}
4	PO_4^{3+}, SO_4^{2-}, Na^+, HCO_3^-
3	OH^-, F^-, Cl^-, Br^-, NO_3^-, K^+, NH_4^+

Table 3. Enthalpy and Free Energy

Temperature of 298.15 K (25°C)			
Species and formula	**Formula Weight**	**ΔH^o_f kcal/mol**	**ΔG^o_f kcal/mol**
Ba^{2+} (aq)	137.34	-128.50	-134.02
$BaSO_4$ (barite)	233.402	-352.1	-325.6
Ca^{2+} (aq)	40.08	-129.74	-132.30
$CaSO_4$ (anhydrite)	136.142	-342.76	-315.93
$CaCO_3$ (calcite)	100.089	-288.46	-269.80
CO_3^{2-} (aq)	60.0094	-161.84	-126.17
HCO_3^- (aq)	61.0174	-165.39	-140.26
H^+(aq)	1.0080	0	0
SO_4^{2-} (aq)	96.0616	-217.32	-177.97

1. Debye-Huckel Equation

$$\log \gamma_i = \frac{-Az_i^2\sqrt{I}}{1+Ba_i\sqrt{I}}$$

At 25°C; A=0.5085 and B = 0.3281

2. Ionic Strength

Ionic strength = I = 0.5 * Σ (c_i* z_i^2)

3. Activity

Activity = activity coefficient * concentration

a (*dimensionless*) = γ (*kg/mol*) * *c* (*molality*)

4. Saturation Index

Saturation Index = SI = $\log \frac{IAP}{K_{sat}}$

5. Van't Hoff Equation

$$\log K_2 = \log K_1 - \Delta H_r^o(kcal) * \left[\frac{219.30}{T_2} - 0.7355\right]$$