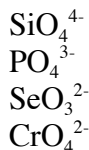


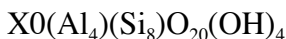
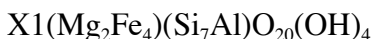
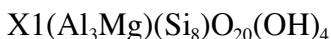
## Problem Set II Solid Phase

1. Determine the electrostatic bond strength in the following bonds:

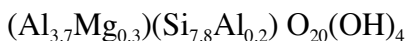


2. What class of **primary silicate minerals** would you expect to find in highly weathered soils such as those found in the Southeast. Explain your answer.

3. Based on the following full unit cell formula formulas determine if the mineral is di-octahedral or tri-octahedral (where X is the charge on the unit cell):



4. Calculate the CEC of this unknown clay mineral based on the following full unit formula:



5. The pH of a soil from the tropics is 5.0. The  $p_{K1}$  values of  $\text{Fe}-\text{OH}_2$  (Fe is 3+) and  $\text{Al}-\text{OH}_2$  are approximately = 7 where  $k_1 = (\text{S}-\text{OH}^{-1/2})(\text{H}^+)/(\text{S}-\text{OH}_2^{+1/2})$  and S= Fe or Al. Calculate the ratio  $\text{S}-\text{OH}^{-1/2}$  to  $\text{S}-\text{OH}_2^{+1/2}$  for each site. Based on these calculations do these functional groups contribute to the soil's CEC.

6. A farmer has been applying poultry manure to his soybean field for 10 years. Recently, the farmer noticed that the soybean crop on part of his field was exhibiting  $\text{Cu}^{2+}$  toxicity symptoms. The farmer had the soil tested from all parts of the field and there was no significant difference in the  $\text{Cu}^{2+}$  concentrations. He also had the soil tested for many other chemical and physical properties and the only difference was the organic matter content. The area exhibiting  $\text{Cu}^{2+}$  toxicity symptoms had 0.40% OM while the rest of the field had around 2.5%. Why do you think these soybeans show copper toxicity while the rest of the field does not?

7. An unknown fraction of organic matter was found to have a molecular weight of 5000 g/mole. The organic matter contained 101 carboxyl groups/mole ( $pK_a = 5.0$ ) and 11 phenolic groups/mole ( $pK_a = 6.0$ ). If the pH is 7.0 what is the CEC of the organic matter?

8. Based on the location and the magnitude of isomorphous substitution explain why smectites are fully expandable and vermiculites are only semi-expandable.
9. Explain why the surface area of 2:1 phyllosilicates decreases in the order montmorillonite > di-vermiculite > Talc > chlorite.
10. Many streams and lakes near industrial areas have been found to contain high levels of trace metals (e.g.  $\text{Pb}^{2+}$ ,  $\text{Cu}^{2+}$ ) in their sediments. However, when one analyzes the water, the concentration of these same metals is below EPA's drinking water standard (MCL = maximum contaminant level). Using your knowledge of the solid phase and its chemistry explain a plausible reason for the above results.
11. Tropical soils (dominated by Al- Fe-oxides and kaolinite) have CECs that greatly fluctuate with pH. In contrast temperate soils (2:1 clay minerals) have CECs that remain relatively constant with changes in pH. Based on the mineralogy provide an explanation for these results. Would you expect tropical soils to have a higher CEC than temperate soils at a pH of 5.5.
12. You are an expert soil chemist working for the Department of Environmental Quality (DEQ) for the state of Florida. You are called to a metal plating site where there has been a wastewater spill releasing high concentrations of trace elements (Cu, Co, Pb etc.). The soils are high in stable humus (8 - 15 %) and the majority of the mineral matter is sandy in nature. One of the local "so-called" soil experts has been causing a great deal of public concern by telling the community that since these soils are sandy that much of these trace elements will leach to the surficial aquifer and contaminate the local groundwater supply. Do you agree with this statement? Why or why not?

13. From the list of ionic radii below:

Ion	Radius ( $\text{\AA}$ )
$\text{Li}^+$	0.78
$\text{Na}^+$	0.98
$\text{K}^+$	1.33
$\text{Mg}^{2+}$	0.78
$\text{Ca}^{2+}$	1.06
$\text{Sr}^{2+}$	1.27
$\text{Ba}^{2+}$	1.43
$\text{Al}^{3+}$	0.57
$\text{Si}^{4+}$	0.39
$\text{Fe}^{2+}$	0.83
$\text{Fe}^{3+}$	0.67
$\text{O}^{2-}$	1.32

Determine which metal ions are likely to substitute into (1) the octahedral sheet (2) the tetrahedral sheet or 3) neither sheet of layer silicates