PROBLEM SET V
ION EXCHANGE

1. Ten grams of soil were shaken with 100 mls 1 N NH_4OAc and allowed to stand for two hours. 10 mls of the extract contained 2 mg Ca^{2+}, 2 mg Mg^{2+}, and 3 mg K^{+}. What is the CEC of the soil?

2. A unknown fraction of organic matter was found to have a molecular weight of 3600 g/mole. The organic matter contained 9 carboxyl groups/mole (pka=5.0), 5 phenolic groups/mole (pka=6.0), and 3 alcoholic groups/mole (pka=9.0). If the pH is 7.0 what is the CEC of the organic matter.

3. You are a soil scientist working for the New Mexico extension service. A farmer wants to irrigate his crops, however, his only source of irrigation water has moderate concentrations of Na+ which may cause poor soil structure and damage his crop. There are no other sources of irrigation water and if the farmer doesn't irrigate he will lose his entire crop. Can you suggest a possible solution to this problem.

4. You want to determine the CEC of a soil that is high in micaceous minerals (micas, vermiculite, etc.). Would you use KCl and/or NH_4OAc as the saturating or replacing solutions. Justify your answer.

5. A sample of vermiculite is brought to your soil chemistry lab so you can determine its CEC. You measure the CEC using Mg^{2+} as the saturating cation and Ba^{2+} as the displacing cation. The results indicate a CEC of 8 $cmol_+/Kg$. Can you give a possible explanation why this value is so low and a way to determine if it is valid.

6. Given the following laboratory results explain reason/mechanism for the increased CEC with an increase in pH:

Mineralogy: 2:1 layer silicates (micas, vermiculites, smectites), Al and Fe oxides, low OM (< 0.4%).

CEC (cmol(c)/Kg)	pH
5	5.0
8	6.0
12	7.0

7. Explain why Fe, Al, and Mn oxides as well as amorphous Al, Fe oxides and amorphous Al silicates contribute little to the CEC of SE soils.

8. If a soil pH is equal to 7 would you expect the exchange complex to have much exchangeable Al^{3+} or Fe^{3+}? Why?

9. Two soils both have a pH of 7.0. The first soil is dominated by 2:1 layer silicates and has an organic matter content of 8%. The second soil is dominated by kaolinite and oxides of Fe and Al. If the pH of each soil was reduced to 4.5 would either soil exhibit any AEC? Justify your answer.

10. Given the following data for Cl^- and K^+ adsorption on a highly weathered oxisol:

pH	Cl- adsorbed (cmoles/kg)	K+ adsorbed (cmoles/kg)
3.2	2.6	0.76
3.4	2.3	0.81
3.75	1.7	0.64
4.1	1.4	0.71
4.85	0.70	1.34
6.4	0.055	2.42
6.7	0.052	3.31

(1) Graph CEC, AEC, and net charge as a function of pH. Determine the PZC of the soil.
(2) Is there any indication that this soil has some permanent charge?
(3) At what pH would this soil be in it most flocculated state?

11. The base saturation of a soil is 10%. You place 10 grams of soil into two different centrifuge tubes. 50 mls of 0.01 M NaCl is added to the first tube while 50 mls of 0.01 M $CaCl_2$ is added to the second tube. The tubes were equilibrated for two hours on a reciprocal shaker centrifuged, rinsed free of salt and the base saturation measured again. Based on the displacing power of cations which soil would have the greater base saturation. Explain your answer thoroughly.

12. Suspensions of clay sized FeOOH in 0.001 M NaCl were adjusted over a range of pH with NaOH and HCl, then shaken and allowed to settle in test tubes. One day later, light transmittance through the undisturbed supernatents was measured. The results were as follows:

pH	4.18	4.64	5.06	5.88	6.88	7.28	7.75	8.54	8.74
transmittance (%)	9.4	21.4	41.9	70.2	91.5	88.0	59.8	57.6	49.5

(a) explain the results based on surface charge
(b) what is the PZC of the oxide based on the experiment

14. If K^+ has a distribution coefficient of 10 for a particular soil, would you expect it to be leached readily through the soil profile?

15. Recently, researchers have discovered that Ruthenium oxides have a very high affinity for trace metal contaminants such as Pb and As. There is interest in using this material in wastewater treatment applications. Below are electrophoretic mobility data for a Ru-oxide before and after adsorption of Pb. Based on this data plot EM (y-axis) vs. pH and determine the IEP (PZC) for the Ru-oxide before and after adsorption of Pb. Why are the IEPs different for the Ru-oxides?

Ru-oxide

pH	EM
3	2.14
4	0.231
5	-1.64
6	-2.59
7	-3.64
8	-3.79
9	-3.89
10	-3.95

Ru-oxide/Pb

pH	EM
3	2.54
4	0.863
5	-1.02
6	-2.15
7	-3.14
8	-3.41
9	-3.45
10	-3.61