1.) Please define, explain, diagram, or show how to calculate the following: (2 points each)

Soil Fertility

Soil Productivity

Justus Von Liebig’s "Law of the Minimum":

Apoplastic Transport:

Soil pH Buffer Capacity:

Cation Exchange Capacity:

Percent Base Saturation:

Total points this page = 14 out of 100.
2.) What is the $H^+$ concentration of 0.00000175 M $H_2SO_4$? (include units) (2 points)

3.) What is the pH of the solution given in Question 2? (3 points)

4.) I have a sulfuric acid ($H_2SO_4$) solution with a pH of 5.2. How many moles of $H_2SO_4$ are there per liter of solution? (3 points)

5.) How many milligrams of $H_2SO_4$ are there per liter of solution in Question 4 if we assume that activity equals concentration? (atomic weights (g/mole): H = 1.01, S = 32.06, O = 16.00) (3 points)

5.) What is the pOH of the solution in question 4? (2 points)

6.) I have two solutions of potassium sulfate ($K_2SO_4$) with a pH of 6.3
   Solution A is a 0.05 M $K_2SO_4$ solution
   Solution B is a 0.50 M $K_2SO_4$ solution
   Based on your knowledge of the difference between activity and concentration:
   a. Which solution (A or B) has a higher $H^+$ concentration? (1 point)
   b. Why? (2 points)

Total points this page = 16 out of 100.

7.) A golf course superintendent calls you and says that the grass in one of his fairways keeps dying even though he gives it plenty of water and fertilizer and that compaction is not a
You ask him the soil pH and he says, "Why do you care about soil pH?" You give him the following 4 (four) reasons why soil pH is so important. (4 points, 1 point each)

1.

2.

3.

4.

8.) Given: (molecular weight of ZnSO₄ = 161.43 g/mole, and atomic weight of Zn = 65.37 g/mole, S = 32.06 g/mole, O = 16.0 g/mole): Show Your Work and Include Units!!!

What is the equivalent weight of ZnSO₄? (3 points)

What is the milliequivalent weight of ZnSO₄? (1 point)

9.) We know that the molecular weight of MgCO₃ = 84.3 g mole⁻¹, (the atomic weight of Mg = 24.3 g mole⁻¹, C = 12 g mole⁻¹, O = 16 g mole⁻¹, and H = 1 g mole⁻¹) and that the equivalent weight of MgCO₃ = 42.15 g mole⁻¹. We also know that the molecular weight of CaCO₃ is 100 g mole⁻¹ and that the equivalent weight of CaCO₃ is 50 g mole⁻¹. Show all work!!!

What is the calcium carbonate equivalent (CCE) of MgCO₃? (3 points)

10.) If the sieve analysis of the MgCO₃ from Question 9 showed that 80 percent of this material passed an 8-mesh sieve and 40 percent of it passed a 60-mesh sieve:

What is the Fineness Factor for this material in the U.S.A.? (3 points)

What is the relative neutralizing value (RNV) of this material? (2 points)

11.) Please list the 3 (three) criteria that must be met for an element to be considered essential for the growth and development of higher plants. (6 points, 2 points each)

Total points this page = 16 out of 100.
13.) Given the following:
Silty loam soil:
- Organic matter content = 2.3%
- Clay content = 22%
  - 35% montmorillonite
  - 50% illite
  - 15% kaolinite

Please estimate the CEC of this soil. **Show all work!!!** (9 points)

14.) **(6 points, 1.5 points each)**
As secondary clay minerals form in our Midwestern soils, permanent negative charge is created through a process known as __________________________ ________________________. During this process, __________________________ partially replaces __________________________ in the tetrahedral layers and iron or magnesium partially replace __________________________ in the octahedral layers as the clay minerals precipitate.

14.) **(4.5 points, 1.5 point each)**
In soils, we measure ________________ acidity with a pH meter in a 1:1 (soil:water) slurry.

If we were to add a nonbuffered salt solution instead of water to the soil, we would measure the ________________ acidity in the soil. If we titrated the soil with a base until we reached a specific pH, we would be measuring the ________________ acidity of the soil.

**Total points this page = 25.5 out of 100.**
15.) Please complete the figure below to show how both clay mineral CEC and organic matter CEC change with pH to change total CEC. Include and label the sources of both permanent and pH dependent charge in your diagram where appropriate. (9 points)

```
\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure.png}
\caption{Diagram showing the relationship between total CEC and pH.}
\end{figure}
```

16.) Based on the following information:
Wheat crop transpired 2.8 million lbs of water
Root volume was 1.2 % of soil volume all the way to 12 inches
Wheat crop accumulates 28 lb P/acre

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Soil solution concentration</th>
<th>Total available in top 12 inches</th>
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</thead>
<tbody>
<tr>
<td>P</td>
<td>0.11 mg L(^{-1})</td>
<td>175 lb/acre</td>
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Please calculate how many lbs P acre\(^{-1}\) would be delivered to the wheat crop via the following mechanisms: Show all work!!

**Root Interception:** (2.5 points)

**Mass Flow:** (2.5 points)

**Diffusion:** (2.5 points)

15.) The lyotropic series ranks cations as to the strength with which they are retained on exchange sites. We listed the lyotropic series as follows $\text{Al}^{3+} > \text{H}^+ > \text{Ca}^{2+} > \text{Mg}^{2+} > \text{K}^+$.
NH₄⁺ > Na⁺. What two factors contribute to these differences in soil cation retention? (2 points)

17.) Carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, and iron are all considered essential for the growth and development of higher plants. There are 10 (ten) other plant-essential elements. Please complete the table below for these other ten plant-essential elements. (10 points, 0.5 points each)

<table>
<thead>
<tr>
<th>Correct Spelling of Element</th>
<th>One ionic form taken up by plants</th>
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Total points this page = 12 out of 100.