I. List the remaining five macronutrients (primary and secondary) for plant growth (correctly spelled) and their chemically available form for uptake - Do not list C, H, and O. (5 points).

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Correct Form(s) and Valence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. _______ Potassium _______</td>
<td>( K^+ )</td>
</tr>
<tr>
<td>2. _______</td>
<td></td>
</tr>
<tr>
<td>3. _______</td>
<td></td>
</tr>
<tr>
<td>4. _______</td>
<td></td>
</tr>
<tr>
<td>5. _______</td>
<td></td>
</tr>
<tr>
<td>6. _______</td>
<td></td>
</tr>
</tbody>
</table>

II. Briefly state the physiological role in the plant of each of the nutrients listed: (4 points)

Phosphorus -

Magnesium –

III. Spell the nutrient name and list the plant available form for these two nutrients: (2 points)

Mo ________________ ____________

Mn ________________ ____________
IV. Nutrient Deficiency Photographs – State the nutrient deficiency observed. (6 pts.)

Deficiency 1

Deficiency 2

Deficiency 3

V. Nutrient Movement to Roots

Use the following data to help you answer the questions below:

Corn crop uses 15 inches of rain (this much water moves through the plant)
Root volume is 0.5% of soil volume
One acre = 43,560 ft²
Corn crop requires 200 lbs N/A
1 ft³ of H₂O = 62.4 lbs.

Nutrient concentrations in soil solution and total available nutrients in the root zone:

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Soil solution concentration ( \text{mg L}^{-1} )</th>
<th>Total available in top 12 inches ( \text{lb/acre} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{NO}_3^- )</td>
<td>35</td>
<td>180</td>
</tr>
<tr>
<td>( \text{NH}_4^+ )</td>
<td>5</td>
<td>20</td>
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</table>

Calculate how much N/acre would be delivered to the corn crop via the following mechanisms – remember both ammonium and nitrate are taken up by the plant: (8 points total, show all work for full or partial credit!!)

Root Interception (2 points)

Mass Flow (4 points total, 2 points for the amount of water used)

Diffusion (2 points)
VI. We know that the molecular weight of Ca(OH)₂ = 74 g mole⁻¹, (the atomic weight of Ca = 40 g mole⁻¹, O = 16 g mole⁻¹, and H = 1 g mole⁻¹). What is the calcium carbonate equivalent (CCE) of Ca(OH)₂ - the molecular weight of CaCO₃ is 100 g? Show work for full or partial credit!!! (3 points)

VII. If the sieve analysis of dolomitic lime showed that 100 percent of this material passed an 8-mesh sieve and 60 percent of it passed a 60-mesh sieve: (Remember effectiveness of material between 8 and 60 mesh is 50% and less than 60 mesh is 100%)

What is the Fineness Factor for this material? Show your work!!! (3 points)

VIII. What is the relative neutralizing value (RNV) of a limestone having a Fineness Factor of 90 and a CCE (calcium carbonate equivalent) of 110%? Show your work!!! (2 points)

\[ \text{RNV} = \]__________

Would you expect this limestone to be dolomitic lime or calcitic lime? _____________ (1pt)

Justify your answer to the above question: ________________________________ (1 pt)

IX. Calculating Lime Requirement

Given the following:
Silty clay loam soil: cation exchange capacity (CEC) = 20 cmol(+) kg⁻¹ = 20 meq 100g⁻¹
Initial pH = 5.2 and 45% base saturation
Desired pH = 6.7 and _____ % base saturation - - Write in your estimate of %BS (1 pt)

How much pure CaCO₃ (molecular weight of CaCO₃ = 100 g mole⁻¹) with a RNV of 100% do we need to add to our soil to raise the pH to 6.7 if we assume that one mole of Ca²⁺ will displace two moles of H⁺? Assume this calculation will be made on a per acre basis (2 million lbs soil acre⁻¹).

Show your work for full or partial credit!!! (5 points)
X. We often talk about CEC as if it was a constant value. However, in reality we know this is not true because soil organic matter and clay minerals both have pH-dependent charge. What happens to soil CEC when we increase the pH of our soils here in the Midwestern U.S.? Does it increase slightly or decrease slightly? (1 point)

XI. List or diagram one source of pH-dependent charge in clays or hydrous oxides. (1 point)

XII. Give two examples of isomorphous substitution (list both the original ions and the replacing ions) and indicate in which sheet the substitution occurs (octahedral or tetrahedral). (4 points)

XIII. Define, explain, or diagram the following terms: (6 points, 3 points each)

Morrill Act:

Symplastic Transport:

XIV. Explain why $K^+$ is held more tightly than $Na^+$ by soil cation exchange sites? (3 points)
XV. Answer the following questions based on the Soil Test Report on the last page of your exam.

1. How many ppm of phosphorus does SAMPLE 2 contain. (Assume 2,000,000 lb soil/A) (1 pts.)

2. Calculate the meq of H, and Ca/100g in SAMPLE 2 (values for Mg and K are provided) and calculate the soils CEC. (6 points)
   
   H _____________ meq/100  (Use the SMP Buffer pH/ Lime Index to help you)
   
   K _____________ meq/100g
   
   Ca _____________ meq/100g
   
   Mg _____________ meq/100g
   
   CEC _____________ meq/100g

3. For SAMPLE 4, should you raise pH with dolomitic or calcitic lime? ________ (1 pt)

4. Explain why SAMPLES 1 and 4 do not have the same Lime Index (Buffer pH) value even though they have the same soil pH (5.9). (2 pts.)

XVI. Soil Monoliths - Look at the two soil monoliths on display and answer these questions:

   Soil A – What would you estimate the CEC of the surface horizon of this Indiana soil to be assuming the clay content is 30% – Show calculations (3 points)

   Soil B – Discuss how the mineralogy and CEC might differ in Soil B compared to Soil A. This soil also contains 30% clay. (3 points)

   Soil C – You determine the CEC of this soil using the summation method and find that the meq of Ca / 100 g in this soil equals 52 giving the soil a CEC greater than 60. Can this be right for this light colored soil with a clay content of 12% ??? How could you get the correct CEC or determine if you actually do have an error in the CEC of this soil? (3 points) OPTIONAL - BONUS QUESTION
Multiple Choice

Select the best answer to each question (2 points each)

___  1. Which of these macronutrients is most associated with stomate opening and closing, disease and lodging resistance and protein synthesis. It is considered to be important to water relations in the plant.
   A. N
   B. P
   C. K
   D. S

___  2. The availability of Fe, Mn, Zn, and Cu increases as soil pH
   A. increases
   B. decreases
   C. exceeds 8.3

___  3. A soil containing 10% kaolinite, 5% montmorillonite, and 20% illite and 2% organic matter would probably have a CEC of approximately
   A. 6 meq/100 g
   B. 16 meq/100 g
   C. 27 meq/100 g
   D. 34 meq/100 g

___  4. Under what conditions would a soil most likely have a significant anion exchange capacity
   A. a midwestern soil having a pH of 6.8 and containing predominantly illite clay
   B. a highly weathered soil containing kaolinite and hydrous oxides of iron and aluminum at pH 4.3
   C. a midwestern soil with predominantly montmorillonite clay and a pH of 6.2
   D. an alluvial soil along the Amazon River with predominately montmorillonite and kaolinite and having a pH of 6.2.

___  5. Most of the cation exchange capacity on organic matter originates from:
   A. dissociation of H from carboxylic acid groups and is pH dependent
   B. isomorphic substitution and is pH dependent
   C. dissociation of H from carboxylic acid groups and is not pH dependent
   D. isomorphic substitution and is not pH dependent
   E. Answers C and D
6. The typical cation distribution on the exchange sites of a fertile Indiana soil with a pH 6.5 would have the relative milliequivalents of

A. acidic cations greater than basic cations with Ca and Mg being in greater amounts than K and Na
B. acidic cations less than basic cations with Ca and Mg being in lesser amounts than K and Na
C. acidic cations less than basic cations with Ca and Mg being in greater amounts than K and Na
D. acidic cations greater than basic cations with Ca and Mg in lesser amounts than K and Na

7. A soil with a hydrogen ion concentration of $4.0 \times 10^{-5}$ N would have a pH of

A. 4.0  \quad \log 3 = 0.48
B. 5.0  \quad \log 4 = 0.60
C. 5.4  \quad \log 5 = 0.70
D. 4.4
E. 4.7

8. A soil with a pH of 4.7 would have most of its acidity as

A. active acidity.
B. reserve acidity.

9. Gypsum would be most useful in reclaiming

A. soils high in CaCO$_3$
B. acid soils
C. midwestern soils with pH 7.0 having poor soil structure due to compaction
D. saline soils
E. sodic soils

10. If an acre of soil requires 5,000 pounds of pure calcium carbonate to raise its pH from 5 to 6, how many pounds of sulfur would it require to lower the pH from 6 to 5 (Formula weight: CaCO$_3$ = 100 g, S = 32 g).

A. 1000 lb
B. 1600 lb
C. 3200 lb
D. 5000 lb
E. 15,600 lb
11. Which of these materials is a good soil acidifying material, is very insoluble in water, and requires microbial activity to release acidity into the soil?

   A. iron sulfate  
   B. sulfur  
   C. ammonium sulfate  
   D. gypsum

12 – 14. Answer Questions 12 thru 14 from the following choices  
(Answers may be used more than once).

   A. root interception  
   B. mass flow  
   C. diffusion

12. Phosphorus and Potassium move to root surfaces predominately by ______.

13. Calcium moves to the root surface predominately by ______.

14. If transpiration of water through the plant is slowed, which of these is most greatly affected ______.
The Berg Soil Testing Lab

Client: Agry 365 Student  
Address: West Lafayette, IN

### IDENTIFICATION

<table>
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<td>2</td>
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### SOIL ANALYSIS

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### FERTILIZER RECOMMENDATIONS

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<th>Footnotes*</th>
<th>Corn 125</th>
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<td>Phosphorus</td>
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<tr>
<td>Potassium</td>
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* See explanation of footnotes on reverse side.