Answer the following essay questions in the space provided: Be complete with your answers. (GOOD LUCK!)

I. List seven (7) micronutrients for plant growth (correctly spelled) and their chemically available form for uptake. (7 points)

<table>
<thead>
<tr>
<th>Micronutrient</th>
<th>Correct Form and Valance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
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<td>7.</td>
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</table>

II. Briefly state the function in the plant of each of the nutrients listed: (6 points)

Phosphorus -

Potassium -

Magnesium -
III. Explain how the chemistry of phosphorus in soils differs from the chemistry of potassium and relate your discussion to the procedures used to soil test for each nutrient. State which nutrient is found on the soil exchange sites and which is complexed with other ions and not found on the exchange sites. (6 points)

IV. A. Define the following terms and indicate the conditions in the soil under which each occurs – moisture, soil organisms, pH, chemical forms of nitrogen: (9 points)

Nitrification

Denitrification

Leaching

B. Discuss the conditions (pH, soil temperature, wind speed, etc) which favor loss of nitrogen from soil due to N volatilization as NH3. Which fertilizer material surface applied would result in the greatest N volatilization (excluding anhydrous ammonia)? (4 points)

C. Would a nitrification inhibitor or a urease inhibitor be of greater value to slow the rate of N volatilization when 45-0-0 is applied to the surface of a soil. (2 points)
V. For each of the **nutrients** listed give the information requested. - Only one answer need be given for each category, except for soil conditions for deficiency.  **(12 points)**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Soil conditions where deficiency might occur</th>
<th>Most susceptible crop in Indiana</th>
<th>Fertilizer source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
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<tr>
<td>Phosphorus</td>
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<td></td>
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<tr>
<td>Manganese</td>
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<td></td>
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<tr>
<td>Molybdenum</td>
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</tbody>
</table>

VI. Briefly explain how each of these fertilizer materials is manufactured.  **(6 points)**

A. NH₃

B. sulfur coated urea

C. 10-34-0
VII. A. Looking at the soil test above, state what two values in this report would be of greatest “concern” and perhaps have the most impact on future management. Justify your answers.  (4 points)

B. The CEC of this soil is 2.6 meq/100g. Show how this CEC was calculated from the data on the left side of the report. (4 points)

C. How many pounds per acre phosphorus are present in this soil. Would this value be a high soil test or a low soil test for growing turf and/or corn? (2 points)
VIII. List the **three nutrients classified as primary nutrients** and the **three nutrients classified as secondary nutrients**. Provide the complete name of the element correctly spelled, the chemical symbol, and one form taken up by plants. Spelling and charge count! (6 points)

<table>
<thead>
<tr>
<th>Element</th>
<th>Symbol</th>
<th>Form taken up by plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Nutrients:</td>
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<td>Secondary Nutrients:</td>
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</table>

IX. When sampling turf on an established golf course briefly describe the steps you would take to obtain quality soil samples – include depth of sampling, number of subsamples per composite, and the strategy you would use to obtain composite samples. (4 points)

X. Calculate the amount of fertilizer required per acre to meet a fertilizer recommendation for 180 lb N, 60 lb P<sub>2</sub>O<sub>5</sub>, and 90 lb K<sub>2</sub>O per acre using the materials listed below: (6 points)

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>45 - 0 – 0</td>
<td>18 – 46 – 0</td>
</tr>
<tr>
<td>0 – 0 - 60</td>
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</tbody>
</table>
XI. Dr. Camberato discussed with you three classifications of soils based on their salt and sodium content. In the table below under **Classification** write which row corresponds to a **saline-sodic soil**, a **sodic soil**, and a **saline soil** based on the information provided in the table. *(6 points)*

<table>
<thead>
<tr>
<th>Classification</th>
<th>ECe, dS m⁻¹</th>
<th>ESP, %</th>
<th>SAR</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 4.0</td>
<td>≥ 15</td>
<td>≥ 12</td>
<td>≥ 8.5</td>
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<tr>
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<td>≥ 4.0</td>
<td>&lt; 15</td>
<td>&lt; 12</td>
<td>&lt; 8.5</td>
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<td></td>
<td>≥ 4.0</td>
<td>≥ 15</td>
<td>≥ 12</td>
<td>≥ 8.5</td>
</tr>
</tbody>
</table>

XII. Explain the terms **ECe** and **ESP, %** *(4 points)*

XIII. Of the three salt affected soils classified above, which soil group is likely to have the greatest physical problems – soil drainage, water infiltration, etc? *(1 point)*

XIV. If a soil has a high percentage of sodium, what two management steps might be taken to reduce the sodium level in the soil? *(2 points)*

XV. Given the following information:

- **Soil A** has a pH of 5.8 and a Buffer pH of 6.8
- **Soil B** has a pH of 5.8 and a Buffer pH of 6.4

A. Which soil has the greater lime requirement? *(2 points)*

B. Which soil has the greater CEC? *(2 points)*

C. What can you tell me about Soil B assuming it has the same organic matter content as Soil A? *(2 points)*
XVI. I have a liming material with a Calcium Carbonate Equivalent (CCE) or a Neutralizing Value (NV) of 96. The sieve analysis of this liming material is as follows:
Percent remaining on an 8 mesh sieve = 0 %
Percent passing an 8 mesh sieve but not a 60 mesh sieve = 30%
Percent passing a 60 mesh sieve = 70 %

What is the Fineness Factor for this material based on the efficiency values provide for Indiana in lecture? (3 points)

What is the Relative Neutralizing Value (RNV) or the Effective Calcium Carbonate Equivalency (ECCE) of this material? (2 points)

XVII. A. How much would it cost per year to fertilize 18 golf greens if you were annually applying 4.0 lbs of N per 1000 ft\(^2\) assuming each green averaged 5,600 sq. ft. and you were using a 25-6-10 fertilizer and it sold for $30.00 per 50 lb bag. (8 points)

\[
\begin{align*}
\text{________ lb of 25-4-8 per 1000 ft}^2 \\
\text{________ lb of 25-4-8 per 1000 ft}^2 \\
\text{________ lb of 25-4-8 per 18 greens} \\
\text{________ (\$) Cost of 25-4-8 for 18 greens}
\end{align*}
\]

B. How many pounds of P\(_2\)O\(_5\) and K\(_2\)O per 1000 ft\(^2\) would be applied annually if you applied the needed 25-4-8 fertilizer to obtain 4 lb of N per 1000 ft\(^2\). (2 points)
XVIII. You have just landed your first job as the head superintendent at White Sands Country Club. On your first day a salesman stops and claims that you need to purchase his newest complete micronutrient fertilizer to aid in greening-up your turf. Before buying this product you should…….. (2 points)

XIX. What micronutrient is MOST commonly deficient in turfgrasses? (2 points)

XX. Matching: (Answers on the right can be used more than once.) (4 points)

_______ Bray P1  N - Nitrogen
_______ SMP Buffer  P - Phosphorus
_______ 1 N NH₄OAc  K - Potassium
_______ Olsen Extractant  LI - Lime Index (Exch. Acidity)
Multiple Choice - Select the letter of the best answer to each question and CIRCLE the letter of the correct answer. (1 point each)

1. Which of these clays contains large amounts of interlayer potassium?
   A) humus
   B) montmorillonite
   C) kaolinite
   D) illite

2. A soil with a pH of 4:
   A) has twice as many hydrogen ions as a soil with a pH of 8.
   B) has four times as many hydrogen ions as a soil with a pH of 8.
   C) has 10,000 times as many hydrogen ions as a soil with a pH of 8.
   D) has a lower availability of Al than a soil with a pH of 8.
   E) answers C and D.

3. The typical cation distribution in a fertile Indiana soil at pH 7 would have the relative milliequivalents of (Hint: Consider the % base saturation of a soil with a pH of 7.)
   A) basic cations greater than acidic cations with Ca > Mg > K > Na
   B) acidic cations greater than basic cations with Ca > K > Na > Mg
   C) basic cations greater than acidic cations with K > Mg > Ca > Na
   D) acidic cations greater than basic cations with Ca > Mg > K > Na
   E) basic cations greater than acidic cations with Mg > K > Ca > Na

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 midwestern soil with predominantly montmorillonite clay and a pH of 6.2
   C) an alluvial soil along the Amazon River with predominantly montmorillonite and some kaolinite and has a pH of 6.2.
   D) a highly weathered soil containing kaolinite and hydrous oxides of iron and aluminum at pH 4.3

5. Ammonium forms of fertilizer tend to ______ soil pH over long term use.
   A) lower
   B) buffer
   C) not change
   D) raise
6. A soil requiring 1 ton of CaCO$_3$ (Eq. Wt. 50 g.) to raise the pH from 6 to 7 would require ______ of sulfur (Eq. Wt. 16 g) to lower the pH from 7 to 6.

   A) no way to approximate this answer  
   B) 3 tons  
   C) 2 tons  
   D) 1 ton  
   E) 1/3 ton

7. If transpiration of water through the plant is slowed, which of these is most greatly affected?

   A) Mass Flow  
   B) Diffusion  
   C) Root Interception  
   D) Fusion

8. Diffusion of ions to roots is probably effective over a distance of

   A) 0.02 to 0.2 cm  
   B) 4 to 8 meters  
   C) 2 to 4 inches  
   D) 1 to 2 feet

9. If a soil contained 800 lb of exchangeable Mg per acre, what would be the maximum pounds of Mg which might reach the plant by root interception? (assume root volume to be 2% of the soil volume)?

   A) 0.2 lb/A  
   B) 80 lb/A  
   C) 160 lb/A  
   D) 16 lb/A  
   E) 0.02 lb/A

10. Most of the potassium and phosphorus reaching plant roots gets to the roots by:

    A) root interception  
    B) mass flow  
    C) diffusion  
    D) complimentary ion carriers.
11. \( \frac{dy}{dx} = (A-Y)C \) This equation is called

A) Liebig's Law of the Minimum and represents growth as a function of nutrients present in the soil
B) Mitscherlich's equation and represents the change in yield for a given change in growth factor (e.g. fertilizer input)
C) Kristie’s Hydroponic Curve
D) Candice's Law of Thermodynamics

12. If a fertilizer label reads 8-32-16 it contains,

A) 8% total N
B) 32% available \( P_2O_5 \)
C) 16% water soluble \( K_2O \)
D) All of the above.

13. This 6-24-12 fertilizer has its potassium (most likely) in what chemical form:

A) \( CaHPO_4 \)
B) \( KC1 \)
C) potassium hydrogen phthalate
D) \( K2O \)
E) \( P2O_5 \)

14. Which of these ions is most susceptible to leaching in a silt loam soil?

A) ammonium
B) nitrate
C) phosphate
D) potassium

15. 28-0-0 is a liquid N fertilizer which weighs 10.5 lb/gal. If you wanted to apply 180 lb N/A, how many gallons of 28-0-0 must you apply?

A) 65
B) 25
C) 10.5
D) 50
E) 90

16. The amount of reserve acidity in a soil:

A) is approximately equal to the amount of active acidity.
B) is located entirely in the soil solution.
C) is less than the amount of active acidity.
D) is 10,000 to 100,000 times that of the active acidity.
17. Mineralization in a light colored silt loam soil would most likely result in an annual release of nitrogen and phosphorus of:

A) N = 2 lb/yr; P = 10 lb/yr.
B) N = 20 lb/yr; P = 2 lb/yr.
C) N = 30 lb/yr; P = 300 lb/yr.
D) N = 300 lb/yr; P = 30 lb/yr.

18. Which one of these nitrogen fertilizers is a "slow release" nitrogen fertilizer requiring microbial breakdown prior to becoming available to plants?

A) urea
B) ureaform
C) IBDU

19. The rock phosphate deposits used for manufacture of the MAJORITY of U.S. phosphorus fertilizers is found in:

A) Canada
B) Tennessee
C) North Carolina
D) Florida
E) Texas

20. High P applications may induce this micronutrient deficiency if it is found in marginal quantities in the soil.

A) Mo
B) Zn
C) Cl
D) B
E) All of these

21. Most of the phosphorus in a light colored Miami silt loam soil with a pH of 5.2 would be:

A) in organic forms
B) in iron and aluminum phosphate forms
C) in the soil solution
D) in available forms for plant uptake
E) answers C and D
22. Browning of older plant leaves along the outer margins is most typical of a ____________ deficiency?

A) K  
B) Fe  
C) P  
D) N  
E) Zn

23. Which of these nutrients shows deficiency symptoms predominately on new, upper plant leaves?

A) N  
B) Fe  
C) K  
D) P  
E) Answers B and C

24. Manganese can cause problems on some soils

A) by inhibiting Al uptake.  
B) by reducing cation exchange.  
C) by being toxic at low pH, deficient at high pH.  
D) by being toxic at high pH, deficient at low pH.

25. A soil with a CEC of 6 cmol$_c$ per kg would also have a CEC of

A) 3 meq / 100 g.  
B) 6 meq / 100 g.  
C) 12 meq / 100g.  
D) 0.6 meq / 100g.  
E) 0.12 meq / 100 g.

26. A soil containing 30% kaolinite clay, 10% illite clay and 1% organic matter would have a CEC of approximately

A) 9 meq/100g  
B) 16 meq/100g  
C) 27 meq/100g  
D) 34 meq/100g
27. Based on your knowledge of liming materials, (if it was cheap) would MgCl\(_2\) be a good liming material?
   
   A) yes  
   B) no  
   C) can't tell without being given its CCE

28. Urea applied to the soil surface will most likely have volatilization and loss of NH\(_3\) when the soil pH is
   
   A) above 7  
   B) below 7

29. The ratio for N:P\(_2\)O\(_5\):K\(_2\)O in turfgrass clippings is approximately:
   
   A) 6:1:4  
   B) 4:3:7  
   C) 4:1:3  
   D) 8:1:3  
   E) 5:7:3

30. Which nutrient is of great concern related to pollution, impacts lake eutrophication, and is restricted in use for lawns in some states (e.g. Minnesota):
   
   A) N  
   B) P  
   C) K  
   D) Fe  
   E) Mg

***** Congratulations on finishing the exam – you deserve 2 Bonus Points!!! *****

I’ve enjoyed having you in class this semester and hope you have a great summer!!!

George