### Essential Nutrient

<table>
<thead>
<tr>
<th>Essential Nutrient</th>
<th>Form taken up by plant including valence</th>
<th>List if Primary, Secondary or Micronutrient</th>
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<tbody>
<tr>
<td>1. Zinc</td>
<td>Zn^{+2}</td>
<td>Micronutrient</td>
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<td>2. Sulfur</td>
<td>SO_{4}^{2-}</td>
<td>Secondary</td>
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<td>13.</td>
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<td>14.</td>
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2. What nutrient deficiencies are shown in the pictures projected. **(4 points)**

a) ______________________________________

b) ______________________________________

c) ______________________________________

d) ______________________________________
3. Please define, explain, diagram, or show how to calculate the following: (14 points - 2 points each)

   Symplastic Transport:

   Soil Buffer Capacity:

   Cation Exchange Capacity:

   Lime Index (or Buffer pH)

   Nutrient Cycling

   Land Grant University

   IBDU

4. A golf course superintendent calls you and says that newly established grass in one of his fairways is turning yellow. You ask if he know the soil pH. He says, "Why do you care about soil pH?" You give him the following three (3) reasons why soil pH is so important. (3 points, 1 point each)

   1)

   2)

   3)
5. We know that the molecular weight of MgCO$_3$ = 84 g mole$^{-1}$, (the atomic weight of Mg = 24 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 MgCO$_3$ = 42 g mole$^{-1}$. We also know that the molecular weight of CaCO$_3$ is 100 g mole$^{-1}$ and that the equivalent weight of CaCO$_3$ is 50 g mole$^{-1}$. 

**Show all work!!!**

A. What is the calcium carbonate equivalent (CCE) of MgCO$_3$? (2 points)

B. If the sieve analysis of the MgCO$_3$ from Question 5A showed that 90 percent of this material passed an 8-mesh sieve and 70 percent of it passed a 60-mesh sieve:

What is the Fineness Factor for this material. (2 points)

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

C. Why is it important to know the relative neutralizing value (RNV) of a liming material? (2 points)

6. **Given the following:**
   Silt loam soil:
   - Organic matter content = 3.8%
   - Clay content:
     - 12% montmorillonite
     - 10% illite

Estimate the CEC of this soil. **Show all work!!!** (3 points)
7. (3 points, 1 points each)

As secondary clay minerals form in our Midwestern soils, **permanent negative charge** is created through a process known as __________________  __________________. During this process aluminum partially replaces __________________ in the tetrahedral layers and iron or magnesium partially replace __________________ in the octahedral layers as the clay minerals form.

8. **Based on the following information:**
   - Creeping bentgrass transpired 3.0 million lbs of water
   - Root volume was 1.5 % of soil volume all the way to 12 inches
   - Creeping bentgrass accumulates 32 lb P/acre

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Soil solution concentration in top 12 inches</th>
<th>Total available</th>
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<tbody>
<tr>
<td>P</td>
<td>0.10 mg L⁻¹</td>
<td>88 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 points)**

   **Mass Flow: (2 points)**

   **Diffusion: (2 points)**

9. The lyotropic series ranks cations as to the strength with which they are retained on exchange sites. We listed the lyotropic series as follows: Al³⁺ > H⁺ > Ca²⁺ > Mg²⁺ > K⁺ = NH₄⁺ > Na⁺. What two factors contribute to these differences in soil cation retention? **(2 points)**

10. List the primary function in the plant of each of these nutrients. **(4 points)**
Nutrient | Primary Function in the Plant
---|---
Magnesium | 
Phosphorus | 
Potassium | 
Nitrogen | 

11. Discuss the relationship of cation exchange capacity to buffering capacity and lime requirement of soils. (3 points)

12. CEC Calculations - Use the following data for problems a through f: (6 points)

<table>
<thead>
<tr>
<th>Soil Test Report</th>
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<tbody>
<tr>
<td>pH</td>
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<td>-----</td>
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<td>?</td>
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a) Calculate the CEC of this soil.

b) Calculate the % Base Saturation of this soil.

c) Calculate the pounds per acre of magnesium in this soil.  
(Hint: AFS = 2,000,000 lbs. and the atomic weight of Mg = 24g)

d) What is the estimated pH of this soil?

e) Should you use dolomitic or calcitic lime to raise the pH of this soil?

f) Calculate the pounds per acre of phosphorus in this soil.
13. If a soil has a CEC of 10 cmol\(^+(+)/kg\) and a base saturation of 40% (pH 5), how much CaCO\(_3\) (Molec. Wt. = 100g) would it take to raise this soil to a pH of 7? (2 points) 

14. List the primary mechanism of root nutrient-contact for the following plant essential nutrients. - root interception, mass flow, or diffusion (2 points)

- Phosphorus
- Potassium:

15. Which of the four steps of soil testing generally gives the greatest source of error? (2 points) 

16. How many individual soil cores should be taken to make one composite soil sample? (2 points) 

17. I am interested in grid sampling my 80 acre field. How much will it change the number of composite samples that I must submit to the lab if I change from using a grid cell size of 200 feet by 200 feet to one of 300 feet by 300 feet. (Remember an acres is 43,560 ft\(^2\).) How many acres would be represented by each grid size? (3 points) 

18. Define a sodic soil and indicate a likely pH for this soil. (2 points) 

19. How much would it cost per year to fertilize 18 golf greens if you were annually applying 5 lbs of N per 1000 ft\(^2\) assuming each green averaged 5,600 sq. ft. and you were using a fertilizer that contained 12 % nitrogen and it sold for $15.00 per 50 lb bag. (4 points)
20. On the axes below, diagram the Build-up, Maintenance, and Drawdown segments of the graph that illustrates the Build-up and Maintenance philosophy of making fertilizer recommendations as described in the Tri-State Fertilizer Recommendation Manual. Include in your diagram the shape of the curve (3 connected straight lines) and the three different regions of the diagram with appropriate labels: Build up, Maintenance, and Drawdown. Also, label the critical level. (4 points)

21. Calculate (do not approximate) the nitrogen release (mineralization) from a soil containing 2% organic matter assuming a 1.5% mineralization rate per year, a C:N ratio for O.M of 10:1 and that O.M. is 60% C. (2 points)

22. On cool season grasses in Indiana, when should the majority of N on turf be applied – Spring, Summer, Fall? WHY? (At least two reasons) (3 points)

23. Explain how CEC and type of clay minerals in soils change when you work in soils of the tropics (Oxisols). (3 points)
24. Define each of the terms below including the forms of nitrogen involved in the transformation and any microorganisms that would maximize these N transformations. (12 points, 4 points each)

**Symbiotic N Fixation** (In addition to the complete definition, be sure to include the genus name for the organism responsible and indicate if autotrophs or heterotrophs)

**Denitrification** (In addition to the complete definition, be sure to include if the organisms involved are heterotrophic or autotrophic, aerobic or anaerobic)

**NH₃ Volatilization** (Indicate what fertilizer materials lead most to this problem and what soil and what application practices and weather conditions enhance this problem.)

25. Diagram and/or discuss the factors that affect the availability of phosphorus in soils. Be complete-list chemical forms that are available and unavailable! In addition, list two extractants that are used to measure “available” soil phosphorus and why pH is so important to P availability. (6 points)
26. Diagram and/or discuss the factors that influence potassium availability in soils. Be complete-discuss what is meant by unavailable K, slowly available K, and available K! In addition, list one extractant that you used to measure “available” potassium and indicate how this extractant works to measure “available” potassium. (6 points)

27. What are the two micronutrients most likely to be deficient in turfgrasses? (2 points)

28. List three conditions when starter fertilizer would be recommended on corn. (3 points)

Multiple Choice Questions--- (1 point each) – Record the best answer to each on the line provided.
1. **How many pounds of N** would be supplied from 11-52-0 if it was used to supply 90 lb P₂O₅/A

   A. 5 lb  B. 19 lb  C. 31 lb  D. 90 lb  E. 818 lb

2. 0-26-12 fertilizer would **most likely** have its source of phosphorus in which chemical form:

   A. (NH₄)₂HPO₄  
   B. P₂O₅  
   C. CaHPO₄  
   D. KCl

3. Application of ammonium forms of fertilizer tend to _______ soil pH over time.

   A. raise  
   B. lower  
   C. not change

4. dy/dx = (A – y) C  --- This equation is called

   A. Mitscherlich’s Equation and represents the change in yield for a given change in growth factor (e.g. fertilizer input) --- with each additional input, change in yield is reduced.  
   B. Liebig’s Law of the Minimum and represents growth as a function of nutrients present in the soil and relates how the nutrient in the lowest amount reduces rate of growth.  
   C. Williams’s Law of Success representing how a student’s grade changes in proportion to the amount they study.  
   D. Walker’s Turf Quality Index representing how turf is better managed in proportion to the grade the Superintendent receives in Agry 365T.

5. The availability of Fe, Mn, Zn, and Cu increases as soil pH

   A. increases  
   B. decreases  
   C. exceeds 8.3

6. A soil with a hydrogen ion concentration of 4.0 X 10⁻⁵ N would have a pH of

   A. 5.0  
   B. 4.4  
   C. 4.0  
   D. 3.0

7. If an acre of soil requires 15,000 pounds of pure calcium carbonate to raise its pH from 5 to 6, approximately how many pounds of sulfur would it require to lower the pH from 6 to 5 (Formula weight: CaCO₃ = 100 g, S = 32 g).
A. 1,000 lb
B. 1,600 lb
C. 3,000 lb
D. 5,000 lb
E. 15,000 lb

8. The parent material (C horizon) of a glacial till derived soil in Indiana contains mostly calcareous till (Ca saturated exchange sites and free CaCO₃). What is the pH of this material?

A. 9.2
B. 8.2
C. 7.2
D. 6.2
E. 5.2

Questions 9 and 10 - Answer these two questions based on the data given

<table>
<thead>
<tr>
<th></th>
<th>Soil A</th>
<th>Soil B</th>
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<tbody>
<tr>
<td>Soil-water pH</td>
<td>5.2</td>
<td>5.2</td>
</tr>
<tr>
<td>SMP Buffer pH</td>
<td>6.7</td>
<td>6.2</td>
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</tbody>
</table>

9. Which of these Indiana soils requires more lime to raise soil pH to 6.5?

A. Soil A  B. Soil B  C. The same, (pH = 5.2)

10. Which Indiana soil has the greater cation exchange capacity (C.E.C)?

A. Soil A  B. Soil B  C. CEC is the same

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

A. Mo
B. B
C. Cl
D. Fe
E. All of these

12. The ratio for N:P₂O₅:K₂O in turfgrass clippings is approximately:

A) 6:14  B) 4:1:3  C) 4:1:7  D) 8:1:3  E) 5:7:3

13. Of the three major fertilizer nutrients, which two are most likely to cause “salt injury” to turf?

A. nitrogen and phosphorus
B. phosphorus and potassium
C. nitrogen and calcium
D. nitrogen and potassium

14. **28-0-0** is a liquid N fertilizer which weighs **10.7 lb/gal**. If you wanted to apply **180 lb N/A**, how many gallons of 28-0-0 must you apply?
   A. 10
   B. 25
   C. 40
   D. 60
   E. 100

15. Soils which are calcareous (pH 7.9) may cause soil tests to have incorrect C.E.C values when C.E.C is determined by the summation method. What is the error?
   A. C.E.C is overestimated.
   B. C.E.C. is underestimated.

16. **This question is worth 1 BONUS POINT!!!** (+1 point)
   A. So, relax.
   B. Congratulations on finishing the exam.
   C. Forget about coursework.
   D. Begin planning for a wonderful summer.
   E. And if you are graduating – stay in touch and have a wonderful life!!!

**Have a fantastic and safe summer !!!**