200 points possible on the exam. However, all scores will be adjusted to percentage. Thus, exam value is BASED ON 100.

Name ____________________________

Exam Score: __________

TA ____________________________

Course Grade: __________

Lab Hour ____________________________

Be sure to show all calculations so that you can receive partial credit for your work!

1) List all 17 plant essential elements. Provide the complete name of the element, one form taken up by plants and list if the nutrient is a macro- or micro-nutrient. **Spelling and charge count!** (0.5 points each, 25 points)

<table>
<thead>
<tr>
<th>Essential Nutrient</th>
<th>Form taken up by plant including valence</th>
<th>Macro or Micro</th>
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<tbody>
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<td>17.</td>
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</table>

2) List the three nutrients categorized as **secondary**: ____________ ____________ ____________ (3 points)
3) Define or explain the following terms as they relate to Soil Fertility: 
**(3 points each, 15 points total)**

- Soil Productivity including the role of Soil Fertility:
- Cation Exchange Capacity
- pH (and indicate the normal range found for soils in the Midwest)
- Buffer pH or Lime Index:
- Liebig’s Law of the Minimum

4) **Define each of the terms** below and **list forms of nitrogen and the conditions** - soil pH (low, near neutral, high), temperature (cold, warm, hot), and moisture (dry, moist, saturated) - that would **maximize** the rates of the following N transformations. **(3 points each, 12 points total)**

- Nitrification:
- Denitrification:
- Volatilization (assume N will be surface applied as urea):
- Symbiotic Nitrogen Fixation
5) **Provide the general formulae** needed to calculate root nutrient contact via the following three mechanisms. (3 points each, 9 points)

   Root Interception:

   Mass Flow:

   Diffusion:

6) **What two factors control the differences in cation retention in soils** (the lyotropic series: why ions are held in this order Al > Ca > Mg > K > Na)? (2 points each, 4 points)

   1. 
   
   2. 

7) a. **Does the cation exchange capacity of midwestern soils** (for example, a Mollisol) increase or decrease when soil pH increases? (1 point)

   b. **Why?** (3 points)

8) **Discuss the precautions which must be taken** when applying sewage sludge to land. List two criteria which must be met in order to not exceed the "legal limits" for sludge applications. (6 points)

9) **Given the following:**
Conventionally tilled soil – Soil A
Crop to be grown: Corn with 180 bu/acre yield potential
Previous crop: Soybeans (only corn and soybeans are planted to this field).

SOIL TEST REPORT

<table>
<thead>
<tr>
<th>Soil</th>
<th>pH</th>
<th>Buffer pH</th>
<th>Organic matter (%)</th>
<th>P (Bray P1)</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>CEC cmol(+) kg⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5.6</td>
<td>6.7</td>
<td>2.8</td>
<td>10</td>
<td>156</td>
<td>1320</td>
<td>40</td>
<td>10.9</td>
</tr>
<tr>
<td>B</td>
<td>5.6</td>
<td>6.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>C</td>
<td>5.2</td>
<td>6.9</td>
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a. What are the correct fertilizer recommendations for N, P₂O₅, and K₂O for growing corn assuming it is to be grown on Soil A under the conditions listed above? Use the Tri-State Recommendation Manual to make the recommendations: use tables or equations as appropriate. (6 points)

N ___________ lb/A  P₂O₅ __________ lb/A  K₂O __________ lb/A

b. Using the data presented above, which soil – Soil A or Soil B – has the higher CEC? (3 points)

c. Calculate and list the cmol(+) kg⁻¹ (meq/100g) for K, Ca, and Mg in Soil A. (6 points)
[Atomic weights (g/mol): K = 39, Ca = 40, Mg = 24]

d. What is the percent base saturation of Soil A? (2 points)

e. What is the exchangeable acidity of Soil A?
   – Hint: There are two different ways this can be calculated? (3 points)
f. This field (from the soil test on the previous page – Soil A) produces a pretty good corn crop however, in the last few years, areas in the field have had corn plants with chlorotic striping on lower leaves. What is the most probable nutrient deficiency and how would you correct it? (3 points)

g. What is the recommended pH for this soil using the crop rotation shown? (2 points)

h. How much limestone (RNV = 75) should you apply to this soil? Show the equation(s) you used and the assumptions made. Refer to the Tri-State Manual to help make this recommendation and the calculations. (4 points)

i. Soybeans grown on this farm on Soil C have been showing nitrogen deficiency except along the gravel road leading to the farm. I regularly use Rhizobium inoculum on the seed but I still seem to have this problem. WHY? (3 points)

10) The primary function in the plant of each of these nutrients is (6 points)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Primary Function in the Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium</td>
<td></td>
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<tr>
<td>Phosphorus</td>
<td></td>
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<tr>
<td>Potassium</td>
<td></td>
</tr>
</tbody>
</table>

11) List three common characteristics of “Miracle Products” as discussed in lecture. (6 points)

1.

2.

3.
12). Briefly describe what forms and relative quantities of K that are present in the soil as available K, slowly available K, and as unavailable K. Also, what common extracting procedure is used to measure available K in soil testing labs? (6 points)

13) Mitscherlich Equation

A. Briefly explain each of the terms in the Mitscherlich equation and then summarize the meaning of the equation. (4 points)

\[ \frac{dy}{dx} = (A-y) c \]

14) Contrast and compare the concepts of applying fertilizer for crops based on: (6 points)

A. Nutrient Sufficiency Approach.

B. Build-up and Maintenance Approach.

15) Briefly explain the difference in availability and release rate of nitrogen applied as ureaformaldehyde and sulfur coated urea. What conditions influence the availability of each fertilizer source. (6 points)

16) A. Using the Manure Analysis Report attached to the last page of your exam, calculate the amount of manure (in tons per acre) that must be applied to provide the recommended P₂O₅
for next year’s corn crop. The fertilizer recommendation is for: **N: 180 lb/A,**
**P₂O₅: 80 lb/A, K₂O: 100 lb/A** (2 points)

B. Now calculate the amount of 45-0-0 and 0-0-60 that must be applied to supplement the
nutrients from the manure in order to complete the nutrient needs as recommended above.
Remember the manure has already supplied some N and K₂O! (4 points)

---

**Multiple Choice**

Select the best answer to each question and record your answer in the blank to the left of the question
number. (1.5 pts each)

_____ 1. If a soil contained 300 lb of available K per acre, approximately how many pounds of K might
one expect to get to the plant by root interception?

   A. 0.02 lb/A          B. 6 lb/A          C. 30 lb/A
   D. 60 lb/A           E. 100 lb/A

_____ 2. Phosphorus and potassium move to root surfaces predominately by:

   A. root interception    B. mass flow    C. diffusion

_____ 3. If a fertilizer label reads 8-32-16, it contains:

   A. 8% total N
   B. 32% total P
   C. 14% available P₂O₅
   D. 16% water soluble K
   E. All of the above

_____ 4. Ammonium forms of nitrogen applied to the surface of a soil will most likely result in losses of
NH₃ if the soil pH is:
5. Ammonium phosphate fertilizers applied to acid (pH 4.6) coal mine spoils to promote growth of planted pines (silt loam soil) would most likely result in:

A. most of the N being lost to leaching
B. most of the N being absorbed by the pines as NO₃⁻
C. most of the N being absorbed by the pines as NH₄⁺
D. most of the N being lost to denitrification

6. Which nutrient is most likely to leach in the greatest quantity in a silt loam soil.

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

7. Which of these nitrogen fertilizers contain nitrogen in the nitrate form?

A. 45-0-0   B. 82-0-0   C. 28-0-0   D. 18-46-0

8. Which of these materials would result in the least loss of N when surface applied to no till continuous corn preplant under warm temperature conditions?

A. urea   B. 28-0-0   C. NH₄NO₃   D. 82-0-0

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

A. increases
B. decreases
C. exceeds 8.3

10. 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. 18 meq/100 g
C. 27 meq/100 g
D. 34 meq/100 g

11. 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.

12. 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

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

A. 4.0
B. 5.0
C. 5.4
D. 4.4
E. 4.7

$$\log 3 = 0.48$$
$$\log 4 = 0.60$$
$$\log 5 = 0.70$$

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

A. active acidity.
B. reserve acidity.

15. 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

16. 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

17. 28-0-0 is a liquid N fertilizer which weighs 10.7 lb/gal. If you wanted to apply 150 lb N/A, how many gallons of 28-0-0 must you apply?

A. 65  
B. 50  
C. 10.5  
D. 200  
E. 100

18. If a lawn needs 2.5 lb N, 1 lb P₂O₅ and 2 lb K₂O per 1000 square feet, which of these fertilizers could provide the correct amount of each?

A. 15-6-10  
B. 16-12-8  
C. 10-4-8  
D. 18-5-10

19. How much would 400 pounds of 6-24-12 cost if it sold for $240 per ton.

A. $24  
B. $48  
C. $96  
D. $240  
E. Answer not given

20. Which of these clays is most likely to “fix” (tie-up) phosphorus?

A. montmorillonite  
B. kaolinite  
C. illite  
D. Answers A and C

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

A. CaHPO₄  
B. KCl  
C. Potassium hydrogen phthalate  
D. K₂O  
E. P₂O₅

22. The mined deposits used for manufacture of the MAJORITY of U.S. potassium fertilizers are found in:

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

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

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

24. The primary form of phosphorus used in manufacturing P fertilizers is:

A. potassium pyrophosphate  
B. aluminum hydrogen phosphate  
C. apatite  
D. gypsum  
E. P₂O₅

25. A tissue analysis for corn was found to contain 2.6% N, 0.38% P and 0.42% K. Which element is most likely hindering growth?

A. N  
B. P  
C. K

26. Interveinal chlorosis of young plant leaves is most typical of a ___________ deficiency?

A. K  
B. B  
C. P  
D. N  
E. Zn

27. Which of these micronutrients increases its availability with increasing soil pH?

A. Mn  
B. Fe  
C. Mo  
D. Zn  
E. Cu

28. Poor growth of alfalfa (with yellow upper leaves) on a light-colored, deeply leached silt loam soil in Indiana would probably be a result of a ___________ deficiency? (This deficiency is often confused with leaf hopper damage).

A. Ca
29. Which of the following nutrients is less available in organic soils because of chelation?

A. K
B. B
C. P
D. Cu
E. Cl

30. Soil pH is lowered by the long term use of fertilizers containing

A. KCl.
B. Ammonium.
C. Phosphates.
D. nitrates.

31. Under which situations would you recommend band placement of fertilizer for corn?

A. When no-till is used.
B. For early planted corn.
C. For conventional tillage when soil tests for P is 50 lb/A and K is 300 lb/A.
D. All of the above.
E. Answers A and B.

32. Nitrification inhibitors may reduce soil N loss by

A. slowing formation of nitrate when ammonium forms of N are applied.
B. inhibiting urease activity and thus, reducing N loss.
C. slowing the decay of organic matter.
D. by combining with organic matter and chelating N.
E. Answers A and B.

33. Which is True?

A. I’m glad this exam is over.
B. I plan to have a great summer!
C. The instructors of 365 wish you the best and enjoyed having you in class.
D. ALL OF THE ABOVE!!!