I. List 7 of the 8 plant essential **micronutrients** for plant growth. Provide the complete name of the element (spelled correctly) and **one form** taken up by plants. **Spelling and charge count!** (7 points)

<table>
<thead>
<tr>
<th>Essential Nutrient</th>
<th>Form taken up by plant including valence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></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>
<tr>
<td>7.</td>
<td></td>
</tr>
</tbody>
</table>

II. What nutrient deficiencies are shown in the pictures projected. (8 points)

a) ____________________________

b) ____________________________

c) ____________________________

d) ____________________________

III. Define or explain the following terms and indicate their importance to soil fertility: **(2 point each, 4 points total)**

a) Mehlich III, Bray P1, and Olsen

b) Feldspars, Muscovite, and Biotite
IV. The primary function in the plant of each of these nutrients is (3 points)

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

V. CEC Calculations - Use the following data for problems a through i: (8 points)

<table>
<thead>
<tr>
<th>Soil Test Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
</tr>
<tr>
<td>?</td>
</tr>
</tbody>
</table>

a) Calculate the CEC of this soil. 
   (Exchangeable acidity is \([7.0 - 6.4) \times 12 = 7.2\ cmolc/kg\])

b) Calculate the % Base Saturation of this soil.

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.

g) Is P at or above the critical level for corn and soybean production?

h) Is K at or above the critical level for corn and soybean production?

i) Is the critical level for P in turf higher, lower, or the same as it is for corn?
VI. Phosphorus in Soils

A. Label the four arrows shown on the diagram in Part B: (4 points)

1. _________________________  3. _________________________
2. _________________________  4. _________________________

B. Explain the chemistry of soil phosphorus for Boxes A and C shown below. List the forms of phosphorus found in each box, the relative amounts found in soil, and briefly explain how the four numbered processes affect availability of phosphorus to plants. Also, write the predominate available forms (Box B) of phosphorus (including valence) taken up by plants at pH 4.5 ____________ and at pH 7.5 ____________ (6 points)

Organic Unavailable P (Box A)  1  Inorganic Available P (Box B)  3  Inorganic Unavailable P (Box C)
2  4
VII. Discuss the factors that influence potassium availability in soils. Be complete! In addition, list one extractant that you used to measure “available” potassium and indicate how this extractant works to measure “available” potassium. (4 points)

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

IX. Explain how 10-34-0 is manufactured. (2 points)

X. For each of the micronutrients listed, give the information requested. - (6 points)

| Potential Soil Conditions Where Deficiency Might Occur | List Two of the Most Susceptible Crops (
<table>
<thead>
<tr>
<th>(2 conditions for each nutrient)</th>
<th>(2 conditions for each nutrient)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese</td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td></td>
</tr>
<tr>
<td>Boron</td>
<td></td>
</tr>
</tbody>
</table>
VIII. Soil Test Data:

<table>
<thead>
<tr>
<th>Soil</th>
<th>Buffer</th>
<th>O.M.</th>
<th>CEC</th>
<th>Ca</th>
<th>Mg</th>
<th>K</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>pH</td>
<td>%</td>
<td>meq/100g</td>
<td>ppm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green</td>
<td>7.6</td>
<td>1.5</td>
<td>3.2</td>
<td>400</td>
<td>120</td>
<td>130</td>
<td>9</td>
</tr>
</tbody>
</table>

Using the recommendation information below and the soil test data above, determine the amount of 12-7-4 fertilizer that you would use to supply the needed phosphorus and potassium recommended on a golf green that had an area of 8500 ft².

P Recommendations for Turf based on Soil Tests (Michigan State)

<table>
<thead>
<tr>
<th>Soil Test Value</th>
<th>Bray P1 (lbs P / A)</th>
<th>Lawns, General Grounds, Fairways (lb P₂O₅ / 1000 ft²)</th>
<th>Greens, Tees, Athletic Fields, Establishment Time (lb P₂O₅ / 1000 ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5056 – 65</td>
<td>0.5</td>
<td>10 or less (Very Low)</td>
<td>4.0</td>
</tr>
<tr>
<td>1.0051 – 55</td>
<td>1.0</td>
<td>11 – 15 (Low)</td>
<td>3.0</td>
</tr>
<tr>
<td>1.0046 – 50</td>
<td>1.0</td>
<td>16 – 20</td>
<td>2.5</td>
</tr>
<tr>
<td>1.5041 – 45</td>
<td>2.0</td>
<td>21 – 25</td>
<td>2.0</td>
</tr>
<tr>
<td>2.00536 – 40</td>
<td>2.5</td>
<td>26 – 30</td>
<td>2.0</td>
</tr>
<tr>
<td>2.5041 – 35</td>
<td>3.0</td>
<td>31 – 35 (Medium)</td>
<td>3.0</td>
</tr>
<tr>
<td>3.01026 – 30</td>
<td>3.5</td>
<td>36 – 40</td>
<td>3.5</td>
</tr>
<tr>
<td>3.52041 – 25</td>
<td>4.0</td>
<td>41 – 45</td>
<td>4.0</td>
</tr>
<tr>
<td>4.0</td>
<td></td>
<td>46 – 50 (good range 25–35 ppm)</td>
<td>4.0</td>
</tr>
<tr>
<td>4.5</td>
<td></td>
<td>51 – 55</td>
<td>4.0</td>
</tr>
<tr>
<td>5.0</td>
<td></td>
<td>56 – 65 (High)</td>
<td>4.0</td>
</tr>
</tbody>
</table>

A. How much P₂O₅ and K₂O equivalent must be applied per 1000 ft² based on the soil test data and recommendation tables listed above? (2 points)

_________ lb P₂O₅ / 1000 ft²

B. How much total 12-7-4 must be applied to this 8,500 ft²-green to meet the phosphorus and potassium needs? (3 points)

C. How much will it cost to fertilize this green with 16-7-4 and meet the total phosphorus and potassium needs? 12-7-4 sells for $18 per 50 pound bag. Partial bags must be charged at the $18 rate. (2 points)

D. Do you need to supplement the 12-7-4 fertilizer applications to meet the nitrogen requirements for this newly established golf green, if the annual N recommendation is for 6 pounds per 1000 ft²? If so, how much 37-0-0 would you use on this green to supplement the 12-7-4 fertilizer? (2 points)
X. List two situations when starter fertilizer should be used for corn production. (2 points)

   1.

   2.

XI. List the approximate “sufficiency” percentages of N, P, and K in turf (or corn). (3 points)

   N ________

   P ________

   K ________

XII. Define each of the following terms and explain their importance to soil fertility. (6 points)

   A. 0-0-50

   B. Polyphosphate

   C. Fixed potassium

XIII. Which nutrient is of concern to potential pollution of lakes and streams and is being band in some locations as a component of fertilizers. Justify your answer? (3 points)

XIV. List three reasons why organic food production has received increasingly popularity in recent years. (3 points)

Multiple Choice Questions (2 points each) – Record the best answer to each on the line provided.
1. If a fertilizer label reads 8-32-16, it contains:
   A. 8% organic N
   B. 32% available P₂O₅
   C. 16% total K
   D. All of the above

2. 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 ratio of material to satisfy the recommendation?
   A. 10-4-8
   B. 16-12-8
   C. 15-6-10
   D. 18-5-10

3. 8-32-16 fertilizer would most likely have its source of potassium in which chemical form:
   A. K₂O
   B. P₂O₅
   C. Dicalcium Phosphate
   D. KCl

4. As soil pH increases, the availability of Fe, Mn, Zn, and Cu
   A. increases.
   B. decreases.
   C. does not change.

5. 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

6. The primary form of phosphorus used in manufacturing P fertilizers is:
   A. potassium pyrophosphate.
   B. aluminum hydrogen phosphate.
   C. apatite.
   D. gypsum.
   E. P₂O₅.

7. Manganese can cause problems on some soils by
   A. inhibiting Al uptake.
   B. reducing cation exchange.
C. being toxic at low pH, deficient at high pH.
D. being toxic at high pH, deficient at low pH.

8. The ratio for N:P$_2$O$_5$:K$_2$O in turfgrass clippings is approximately:

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

9. 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

10. Which salt form of Cu, Mn, Zn, and Cu are commonly used to provide these micronutrients in fertilizers?

    A. nitrate
    B. chloride
    C. sulfate
    D. phosphate