Study Questions Exam 4

1. To what does the greenhouse effect refer? List those greenhouse gasses that arise from soil. What effects do deforestation, land drainage and tillage have on soil organic matter and, in turn, on CO_2 loading into the atmosphere?

   Assuming you know the first, CO_2 (respiration), N_2O (anaerobic respiration) and CH_4 (anaerobic respiration). All of these acts result in decomposition of soil organic matter, releasing C from it as CO_2 into the atmosphere.

2. Decomposition of organic matter is faster under anaerobic conditions (True / False).

   This is false because respiration is slower under anaerobic conditions.

3. The C / N ratio of wheat straw is larger than the C / N ratio of clover. Which is microbially decomposed faster?

   The clover is decomposed faster because it contains sufficient N to sustain the population of microbes that is decomposing it.

4. Depression of soluble soil N is greatest following the incorporation of plant residues of which C / N ratio?

   A) 640 / 1 B) 160 / 1 C) 40 / 1 D) 10 / 1

   Residue of the 640 to 1 ratio causes the greatest depression in soluble (available) N because it contains the least N. In contrast, decomposition of the 10 to 1 ratio residue would result in net mineralization (release) of N to the soil. Residue of a ratio of about 24 to 1 has just enough N to sustain the microbial population without using existing available soil N.

5. List the three humic substances in order of increasing molecular weight and resistance to decomposition.

   Fulvic acids, humic acids and humin.

6. Give three benefits of soil organic matter to plants.

   Although soil organic matter contains some growth-stimulation substances, most benefits are indirect. These include increased soil water-holding capacity, increased infiltration / decreased runoff (hence, water conservation), higher CEC, more mineralizable nutrients (like organically-bound N) and many others.

7. What effect does adsorption of soil organic matter onto soil mineral solids have on the decomposition rate of soil organic matter?

It decreases it because organic matter that is adsorbed onto mineral solids is less susceptible to chemical decomposition. It is physically protected.

8. Give three effects of soil organic matter on soil chemical and physical properties.

See # 6 for a few.

9. Soil organic matter leads to soil aggregation and, therefore, enhances infiltration and limits runoff and erosion (True / False).

See # 6.

10. The organic C content of soil A is 1 % and the organic C of soil B is 2 %. All else being equal, through which soil would a pesticide more quickly move?

Many (and probably most) chemicals are adsorbed onto soil organic matter. Therefore, sorption of chemicals in soil A would be less than in soil B and the mobility of chemicals generally faster in soil A than in soil B.

11. Under which climate would one expect the greatest accumulation of soil organic matter?

A) Cool Dry	B) Cool Wet	C) Hot Dry	D) Hot Wet

A cool and wet soil climate would have the greatest accumulation of soil organic matter because production of biomass would be greater where it is wet than dry but cooler temperature would slow decomposition of residue compared to hotter temperature.

12. Under which of the below conditions would one expect to find the highest soil organic matter content?

A) Forest Well-drained	B) Forest Poorly-drained	C) Prairie Well-drained	D) Prairie Poorly-drained

Prairie soils generally have more organic matter than forest soils and, similar to # 11, wetter, more poorly drained soils, have more organic matter than well-drained soils.

13. What effect does tillage have on the content of organic matter in soil?

Over and over, studies have shown that tillage results in a decrease in soil organic matter. Tillage tends to temporarily improve aeration, which accelerates decomposition. The effect applies to the surface soil as a whole and also to soil aggregates –tillage tends to break them up, accelerating the decomposition of organic matter that is trapped and protected in their interior.

14. Give a couple of general physical characteristics of organic soils.

As you know, two are low bulk density (highly organic rather than mineral) and high water-holding capacity.

15. What are two problems encountered when using an organic soil for agricultural production?

One is wind erosion of the dry organic soil (it has to be drained for production, otherwise it would be too wet to do anything with). And when it is comparatively dry, it is well-aerated. Consequently, it is subject to decomposition (subsidence).

16. In what inorganic forms is N taken-up by plants?

Nitrate (NO_3^-) and ammonium (NH_4^+).

17. What is chlorosis? Would chlorosis due to N deficiency be first seen on young or old growth?

It is a yellowing of plant tissue which if due to N deficiency, is first seen on the older parts of the plant since N is mobile and translocated from older to younger, developing parts.

18. Most soil N is in inorganic forms like NO_3^- (nitrate) or NH_4^+ (ammonium) (True / False).

Absolutely not. These comprise only a percent or so of total soil N, most of which is in organic matter.

19. If a soil contains 2 % organic matter, the organic matter is 5 % N by weight and 2 % of the organic matter is decomposed annually, how many kgs of N are mineralized per HFS annually? Ignore immobilization and assume 2,000,000 kg per HFS.

2,000,000 kg / HFS x 0.02 = 40,000 kg organic matter / HFS

40,000 kg organic matter / HFS x 0.02 decomposed / yr =

800 kg organic matter decomposed / HFS-yr

800 kg organic matter decomposed / HFS-yr x 0.05 = 40 kg N released / HFS-yr

20. What is NH_4^+ fixation? Rank vermiculite, smectite and illite in order of increasing tendency for NH_4^+ fixation.

Entrapment of at interlayer positions of these 2:1 aluminosilicate minerals. Among them, vermiculite shows the greatest tendency to fix NH_4^+ and smectite the least.

21. Given the equilibrium $NH_4^+ + OH^- = NH_3 + H_2O$ under which set of conditions would one expect the greatest amount of NH_3 volatilization?

A) alkaline pH wet soil B) alkaline pH dry soil C) acid pH wet soil D) acid pH dry soil

Looking at the above reaction, high concentration of OH- (high pH) favors conversion of NH_4^+ to NH_3, which would be freer to diffuse from the soil if the soil were dry rather than wet.

22. Nitrification is carried out in two steps, first to nitrite, then to nitrate, by different chemautotrophs

$NH_4^+ + 3/2\ O_2 \text{ X } NO_2^- + 2H^+ + H_2O$ A
$NO_2^- + 1/2\ O_2 \text{ X } NO_3^-$ B

What organisms are responsible for step A and step B? Does nitrification typically occur quickly after addition of ammonium to soil?

Nitrosomonas and Nitrobacter, respectively. Most data show that NH_4^+ is fairly rapidly nitrified when added to soil.

23. What are the environmental concerns over nitrate loading in ground and surface water?

Nitrate poisoning (blue baby syndrome, which is actually due to NO_2^- that is produced from NO_3^-) and eutrophication, especially of marine waters.

24. The series of reactions NO_3 6 NO_2 6 NO 6 N_2O 6 N_2 describes what N transformation process?

Denitrification.

25. Under which set of conditions would you expect the above process to proceed fastest?

Factor	Set A	Set B	Set C	Set D
Soil aeration status	aerobic	aerobic	anaerobic	anaerobic
Soil organic matter	high	low	high	low

Since it's an anaerobic process, either C or D, but since it's due to microbial respiration, which depends on carbonaceous substrate, C.

26. What is biological N fixation? Name the enzyme complex responsible.

It is the biological reduction of N_2 from the atmosphere to NH_4^+, finally resulting in incorporation of N into amino acids. It is mediated by the enzyme complex, nitrogenase.

27. Why is biological N fixation such an important process?

It is by far and away the major process or pathway whereby N is added to the biosphere in biochemically usable form.

28. Biological N fixation is favored by high concentration of inorganic N in the soil (True / False).

Many studies have shown that inorganic N inhibits biological N fixation.

29. Name two genera of bacteria involved with symbiotic N fixation in legumes.

Rhizobia and Bradyrhizobia.

30. In what inorganic form is S taken up by plant roots?

Sulfate, SO_4^{2-}.

31. Conversion of S_2^- (sulfide) to SO_4^{2-} (sulfate) occurs in anaerobic soil (True / False).

No, just the opposite. Sulfate is reduced to sulfide under anaerobic conditions in anaerobic respiration.

32. Conversion of S^{2-} to SO_4^{2-} is acidifying (True / False).

Write out a balanced equation of the oxidation of S^{2-} to SO_4^{2-} and you should get sulfuric acid as a product.

33. List a couple of environmental problems associated with S oxidation?

Sulfur from burned fossil fuels ultimately gives sulfuric acid. Similarly, chemically reduced S in wetlands or in mined ore tends to be chemically and biochemically oxidized to sulfuric acid. Thus, acidification of soil and surface waters is the common effect of these different environmental problems associated with S oxidation.

34. What three macronutrients are usually the most limiting to plant growth. Which among these is usually the most limiting? Next?

N > P > K

35. In what inorganic form (or forms) is P taken up by plant roots?

$H_2PO_4^-$ and HPO_4^{2-} because these forms are most common at typical soil pHs.

36. Why are P concentrations in the soil solution typically low?

Various precipitation and adsorption reactions keep the solution concentration of P low. See # 37.

37. What fixation reactions does phosphate undergo in acid soil? Slightly acid to neutral soil? Alkaline soil?

Acid, precipitation with Al and Fe; slightly acid to neutral, adsorption onto soil mineral surfaces (Al and Fe oxides > 1:1 minerals > 2:1 minerals); alkaline soil, precipitation with Ca.

38. Explain why myccorhizae enhance P nutrition of plants.

The root density of the plant is effectively increased. Thus, for P to reach the plant root systems, it must move via mass flow with soil water or diffusion in soil water a shorter distance than otherwise would be the case.

39. What soil pH range is optimal for P availability?

About 5.5 to 7.

40. What major advantage does localized (banded) placement of P fertilizer offer?

The P fixation capacity of the soil in the immediate vicinity of the band is saturated so that fertilizer P near the band remains soluble and available to the plant root system for uptake.

41. Which macronutrient, N, P or K is most abundant in soil?

K but see # 43.

42. List the three general inorganic forms in which K is found in soil. Which form is most abundant? Which is most available for uptake by plants?

Potassium is found in the structure of certain soil minerals (like micas and feldspars). Although this is the largest pool of soil K (~ 90 %), the K in the crystal structure of these minerals is obviously not plant-available. Potassium trapped in interlayer positions of illite and vermiculite (to some degree) makes up ~ 10 % of soil K. This K is considered slowly available. The remaining soil K (other than the small amount that at any time is dissolved in the soil solution) is adsorbed onto soil colloids in exchangeable form. This 1 % to 2 % of total soil K is plant-available.

43. Which aluminosilicate clay minerals fix K^+?

See # 43.

44. What is meant by luxury consumption?

Uptake of a nutrient in excess of amount needed for normal plant growth (common with K).

45. Explain why application of 10 times the recommended amount of a micronutrient may not be such a good idea.

This could push the soil concentration of the micronutrient into the toxic range.

46. Why are deficiency symptoms of most micronutrients first seen on young growth?

They are commonly immobile in the plant. See # 17.

47. What effect does liming have on Mo availability for plant uptake?

Since Mo is more available at higher pHs, liming increases its availability.

48. What effect does liming have on Fe availability for plant uptake? Why?

In most cases (see # 48), however, liming decreases availability. With Fe, for example, increasing the pH leads to increase precipitation as the hydroxide form, $Fe(OH)_3$.

48. Under which of the below soil conditions is the soil solution concentration of Fe and Mn greatest? Why?

High pH and dry
High pH and wet
Low pH and dry
Low pH and wet

Low pH (see # 49) and wet. Anaerobic conditions may exist if the soil is sufficiently wet, resulting in chemical reduction of Fe^{3+} to Fe^{2+} and Mn^{4+} to Mn^{2+} and at any pH, the reduced form is more soluble (less tendency to be precipitated as the hydroxide).

50. Why might the soil solution concentration of P increase under waterlogged conditions?

Hint: Use $FePO_4$ as a model. Write an equation to describe the dissolution of this mineral and consider what happens under anaerobic conditions.

51. What is a chelate and why are chelates used to supply micronutrients?

It is an organo-metallic complex used to increase the total soil solution concentration of certain metal micronutrients (particularly, Cu, Fe, Mn and Zn). In the presence of a chelating ligand (like EDTA), the total solution concentration of metal is greater than if the metal micronutrient was added to the soil as a simple salt.

52. List two ways fixation of micronutrients added to soil is either reduced or avoided.

Banded application (see # 41) or foliar application.

53. What soil pH range is optimal for micronutrient availability?

The same as for P (see # 40). This represents a compromise between increasing solubility and availability of most micronutrients under acid conditions and decreased availability of Mo (see # 48).

54. What soil and management conditions are associated with micronutrient deficiencies.

One management condition is high yield so that micronutrients are removed from the soil in comparatively large amounts in plant harvest. Another is use of high analysis fertilizers which contain little of the micronutrient elements for replenishment. Also, high or low soil pH.