
Soil: A Living System

Soils 201

Midterm #2

October 15, 2001

Total Number of Points: 92

1 Single-Answer Multiple Choice

2 points each. Circle the one solution that answers each question or completes the sentence.

1. The water potential has different components. Which of the following components are dominant in saturated soil?
 - (a) gravity, pressure, and osmotic components ♣
 - (b) gravity, pressure, and matric components
 - (c) pressure, matric, and osmotic components
 - (d) gravity, matric, and osmotic components
 - (e) all of the above
2. The range of plant available water in soil is between
 - (a) 0 bar and -15 bar
 - (b) -0.3 bar and -15 bar ♣
 - (c) 0 and -0.3 bar
 - (d) -0.3 and -30 bar
 - (e) 0 and -30 bar
3. A soil block of 1 m^3 has the following volumetric water at different matric potentials:
 - $\theta_v = 0.54 \text{ m}^3\text{m}^{-3}$ at saturation
 - $\theta_v = 0.28 \text{ m}^3\text{m}^{-3}$ at -0.3 bars
 - $\theta_v = 0.19 \text{ m}^3\text{m}^{-3}$ at -1.5 bars
 - $\theta_v = 0.10 \text{ m}^3\text{m}^{-3}$ at -15 bars

What is the plant available water content in this soil block?

- (a) $0.32 \text{ m}^3\text{m}^{-3}$
- (b) $0.13 \text{ m}^3\text{m}^{-3}$
- (c) $0.18 \text{ m}^3\text{m}^{-3}$ ♣
- (d) $0.10 \text{ m}^3\text{m}^{-3}$
- (e) $0.09 \text{ m}^3\text{m}^{-3}$

4. At the same water content, a sandy soil has _____ a loamy soil.
- (a) a higher matric potential than ♣
 - (b) a lower matric potential than
 - (c) the same matric potential as
5. Consider that plant roots penetrate the soil to a depth of 1 meter and that the soil is uniform. The water content of the soil at the permanent wilting point is $0.15 \text{ cm}^3 \text{ cm}^{-3}$ and at field capacity $0.35 \text{ cm}^3 \text{ cm}^{-3}$. How much water is available to plants in 1 m^3 of soil a few days after a long rainfall? (Hint: $1 \text{ dm}^3 = 1 \text{ Liter}$)
- (a) 350 dm^3
 - (b) 200 dm^3 ♣
 - (c) 150 dm^3
 - (d) 35 dm^3
 - (e) 20 dm^3
6. Darcy's law states that
- (a) the water flow rate is equal to hydraulic conductivity times cross sectional area times potential gradient ♣
 - (b) the water flow rate is equal to hydraulic conductivity times potential difference
 - (c) the water flow rate is equal to hydraulic conductivity times acceleration of gravity
 - (d) none of the above
7. Consider two points in a soil. Point A has a water potential of -15 bars , point B a water potential of -35 bars . The distance between the two points is 2.0 m . What is the potential gradient between the two points?
- (a) -2 bars m^{-1}
 - (b) -5 bars m^{-1}
 - (c) -10 bars m^{-1} ♣
 - (d) -20 bars m^{-1}
 - (e) -30 bars m^{-1}
8. In which direction does water flow in the previous example?
- (a) from A to B ♣
 - (b) from B to A
9. A soil profile consists of a dry loamy soil overlaying a dry sandy soil. When water infiltrates from the soil surface and moves downward under unsaturated conditions
- (a) water will move through the soil as if there is no layering present
 - (b) the sand layer acts like a barrier to water movement for a certain time ♣
 - (c) the sand layer will attract the water as soon as the water reaches the sand layer

10. When examining the kinds of minerals present in the sand fraction, we find that most of the minerals in this fraction belong to
- (a) aluminosilicate minerals
 - (b) primary minerals ♣
 - (c) secondary minerals
11. The net charge of the Si_2O_5 unit is
- (a) +2
 - (b) 0
 - (c) -2 ♣
 - (d) -4
 - (e) -6
12. What is the overall charge of a tetrahedron with the formula AlO_4 ?
- (a) +4
 - (b) +5
 - (c) -4
 - (d) -5 ♣
13. The base unit of pyroxene is
- (a) SiO_2
 - (b) SiO_4
 - (c) Si_2O_6 ♣
 - (d) KAlSi_3O_8
 - (e) $\text{NaAlSi}_3\text{O}_8$
14. Feldspars are
- (a) oxides and hydroxides
 - (b) silicates similar to quartz but with isomorphous substitution of Si with Al ♣
 - (c) double chains silicates
 - (d) carbonates
15. How is the negative charge of the silica tetrahedra compensated in the primary silicate minerals?
- (a) The charge is compensated by sharing oxygen atoms at the corners of the tetrahedra
 - (b) The charge is compensated by isomorphous substitution of silica by aluminum
 - (c) The charge is compensated by auxiliary cations, such as Fe and Mg, embedded in the mineral structure
 - (d) a and b
 - (e) a and c ♣

16. Chinaware is made by
- (a) fusing kaolinite minerals under high temperatures ♣
 - (b) fusing oxides minerals under high temperatures
 - (c) fusing carbonates minerals under high temperatures
17. Isomorphic substitution leads to
- (a) a permanent negative charge of the soil minerals ♣
 - (b) a permanent positive charge of the soil minerals
 - (c) a pH dependent negative charge of the soil minerals
 - (d) a deformation of the mineral structure
18. Isomorphous substitution dominantly in the silicon tetrahedra sheet leads to _____ shrinking/swelling of the clay minerals than isomorphous substitution dominantly in the octahedra sheet.
- (a) the same
 - (b) less ♣
 - (c) more
19. The interlayers in illite
- (a) are characterized by hydrogen bonds
 - (b) are filled with Na and water
 - (c) shrink and swell easily
 - (d) contain K ♣
 - (e) b and c
20. Sesquioxides carry a charge that is
- (a) permanent due to isomorphous substitution
 - (b) variable due to protonation and deprotonation ♣
 - (c) zero
 - (d) positive
 - (e) negative
21. At a high pH, we expect that gibbsite has a _____ charge.
- (a) negative ♣
 - (b) neutral
 - (c) positive

22. The dominant charge of soil particles in tropical climates is
- (a) negative
 - (b) neutral
 - (c) positive ♣
23. The Cation Exchange Capacity (CEC) of a soil refers to
- (a) the affinity of a soil to adsorb anions per unit mass
 - (b) the actual amount of cations that are sorbed at a given time per unit mass
 - (c) the total amount of cations that can potentially sorb per unit mass ♣
 - (d) the ratio of cations and anions at the surface of soil particles
24. What is the mol charge (mol_c) of 24 g of Mg^{2+} ? (atomic weight of Mg is 24 g mol^{-1})
- (a) 1 mol_c
 - (b) 2 mol_c ♣
 - (c) 0.5 mol_c
 - (d) 24 mol_c
 - (e) 12 mol_c
25. Which of the following minerals has the highest Cation Exchange Capacity?
- (a) Kaolinite
 - (b) Chlorite
 - (c) Smectite ♣
 - (d) Quartz

2 Multiple-Answer Multiple Choice

4 points for each problem set. Each problem set below consists of one problem with four possible answers. Each has at least one of the answers listed, but may have two, three or four of the answers listed. Mark "T" for true for each answer that is correct and "F" for each answer that is incorrect.

- The water potential refers to

26. the energy content of water per unit mass T
27. the energy content of water per unit weight T
28. the energy content of water per unit volume T
29. the water content at saturation F

- The matric potential in an unsaturated soil

30. is always smaller or equal zero T
31. is always zero F
32. depends on the water content of the soil T
33. depends on the position below surface of the soil F

- How water flows in soils depends on

34. the potential gradient T
35. the hydraulic conductivity T
36. soil texture and structure T
37. soil color F

- The Field Capacity is

38. is the matric potential at -0.1 bars F
39. is the matric potential at -0.3 bars T
40. is the matric potential at -1 bars F
41. is water content at the potential that holds water against the gravity force a few days after a rain or irrigation event T

- A thin horizontal clay layer embedded in a sandy soil

42. can inhibit vertical water flow through the soil T
43. can cause the soil above the clay layer to hold more water than in the absence of the clay layer T
44. has no effect on water movement whatsoever F
45. can cause water to move horizontally on top of the clay layer T

• Illite is a

46. a 2:1 clay mineral T
47. a 1:1 clay mineral F
48. a 2:1:1 clay mineral F
49. a primary silicate mineral F

• Chlorite is a

50. a mineral characterized by H-bonds in the interlayers F
51. a mineral characterized by a Mg-O octahedron sheet in the interlayers T
52. a 1:1 clay mineral F
53. a 2:1:1 clay mineral T

• The phenomenon of isomorphous substitution

54. refers to the substitution of Fe with Mg in sesquioxides F
55. leads to a weakening of the mineral structure F
56. occurs in the tetrahedron and octahedron units of silicates T
57. leads to a negative charge of the minerals T

• Sesquioxides

58. consist mainly of Si and O F
59. are subject to isomorphous substitution F
60. contribute to shrinking and swelling of soil material F
61. are considered to be secondary soil minerals T

3 Essay Question

4 points for each problem set.

- Describe how plants take up water from the soil?

Water uptake is a passive phenomenon caused by potential differences in the root and the surrounding soil. The plant cells have a lower total potential than the soil solution, caused by high solute concentrations in the cells which lower its osmotic potential.

- Explain the role of soils in a septic tank system by considering (1) which materials are removed from the waste water and (2) how these materials are removed by soil.

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- Soil removes the following materials via the mechanisms in parentheses
 - pathogenic organisms: viruses (inactivation at interfaces), bacteria (filtration, interface reactions), protozoa (filtration), pathogenic worms or other larger organisms (filtration)
 - nitrate (microbial metabolism)
 - phosphate (sorption or fixation at soil minerals, microbial metabolisms)
 - BOD=Biological Oxygen Demand or organic material (microbial metabolism)
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