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# Soil: A Living System

Soils 201

Midterm #2

October 11, 2002

Total Number of Points: 78

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## 1 Single-Answer Multiple Choice

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

1. The water potential refers to
  - (a) the energy content of water per unit mass
  - (b) the energy content of water per unit weight
  - (c) the energy content of water per unit volume
  - (d) none of the above
  - (e) a, b, and c ♣
2. The water potential has different components. Which of the following components are dominant in unsaturated soil?
  - (a) gravity and pressure components
  - (b) gravity and osmotic components
  - (c) pressure and matric components
  - (d) gravity and matric components ♣
  - (e) all of the above
3. The attraction of water molecules among themselves is called
  - (a) surface tension
  - (b) adhesion
  - (c) cohesion ♣
  - (d) adsorption
  - (e) none of the above
4. Which of the following soils could most likely hold the largest amount of plant available water?
  - (a) sand
  - (b) clay ♣
  - (c) silt
  - (d) sandy loam
  - (e) loamy sand

5. A soil block of  $1 \text{ m}^3$  has the following volumetric water at different matric potentials:

- $\theta_v = 0.44 \text{ m}^3\text{m}^{-3}$  at saturation
- $\theta_v = 0.31 \text{ m}^3\text{m}^{-3}$  at  $-0.3$  bars
- $\theta_v = 0.23 \text{ m}^3\text{m}^{-3}$  at  $-1.5$  bars
- $\theta_v = 0.12 \text{ m}^3\text{m}^{-3}$  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)  $0.21 \text{ m}^3\text{m}^{-3}$
- (d)  $0.19 \text{ m}^3\text{m}^{-3}$  ♣
- (e)  $0.08 \text{ m}^3\text{m}^{-3}$

6. If the vegetation uses 7 mm of water each day, how long would the water supply from the previous question last until plants would wilt?

- (a) 24 days
- (b) 27 days ♣
- (c) 30 days
- (d) 33 days

7. The driving force for water movement in soils is

- (a) the gradient of the water potential ♣
- (b) the hydraulic conductivity of the soil material
- (c) the cross sectional area through which water flows
- (d) none of the above

8. Plant roots can take up water from the soil because

- (a) the water in the plant cells has a lower potential than the soil solution ♣
- (b) the osmotic potential in the soil solution is similar to the potential in the root cells
- (c) the water in soil is under pressure and moves freely to the roots
- (d) none of the above

9. What was the motivation that led to the development of Darcy's law?

- (a) Irrigation problems in arid regions
- (b) Water pollution and disinfection problems in Europe ♣
- (c) Seawater intrusion in coastal cities
- (d) Urbanization of the Los Angeles area

10. Consider two points in a soil. Point A has a water potential of  $-10$  bars, point B a water potential of  $-4$  bars. The distance between the two points is  $0.5$  m. What is the potential gradient between the two points?
- (a)  $-12$  bars  $\text{m}^{-1}$  ♣
  - (b)  $-28$  bars  $\text{m}^{-1}$
  - (c)  $-3$  bars  $\text{m}^{-1}$
  - (d)  $-6$  bars  $\text{m}^{-1}$
  - (e)  $-7$  bars  $\text{m}^{-1}$
11. In which direction does water flow in the previous example?
- (a) from A to B
  - (b) from B to A ♣
12. At which of the following matric potentials is the soil water held most tightly?
- (a)  $+5$  bars
  - (b)  $0$  bars
  - (c)  $-1$  bar
  - (d)  $-10$  bar ♣
13. What is the net charge of  $\text{Si}_2\text{O}_7$
- (a)  $+2$
  - (b)  $0$
  - (c)  $-3$
  - (d)  $-4$
  - (e)  $-6$  ♣
14. The negative charge on 2:1 type aluminosilicate minerals is due primarily to
- (a) ionization of surface OH groups
  - (b) substitution of one metallic ion for another in the crystal structure of the clay ♣
  - (c) extremely small size of the individual particles
  - (d) the effect of pH on the presence of  $\text{H}^+$  on the surface of the minerals
  - (e) the preponderance of tetrahedron sheets compared to the octahedron sheets
15. The negative charge associated with smectite clay crystals are due mostly to
- (a) isomorphous substitution of Mg for Al in the octahedral sheet ♣
  - (b) substitution of Al for Mg in the tetrahedral sheet
  - (c) substitution of Si for Al in the tetrahedral sheet
  - (d) OH groups on the external surface of the crystal
16. During isomorphous substitution
- (a) the shape of octahedra and tetrahedra change
  - (b) the overall charge of octahedra and tetrahedra change ♣
  - (c) both the charge and shape of octahedra and tetrahedra change
  - (d) none of the above

17. The swelling and shrinking tendency of some aluminosilicate clays is primarily due to
- (a) the presence of cations attracted by negative charges on the internal surfaces
  - (b) the movement of water molecules in and out of the interlayers of the crystals ♣
  - (c) varying thickness of water films covering the external surface of the particles
  - (d) the high Mg content in the octahedral layers
18. The interlayers in kaolinite
- (a) are characterized by hydrogen bonds ♣
  - (b) are filled with cations and water
  - (c) shrink and swell easily
  - (d) a and b
  - (e) b and c
19. Amphibole silicate minerals consist of
- (a) single silicon tetrahedra
  - (b) chains of silica tetrahedra
  - (c) double chains of silica tetrahedra ♣
  - (d) sheets of silica tetrahedra
  - (e) 3-dimensional grids of silica tetrahedra
20. Allophane differs from other aluminosilicate clays in
- (a) that it contains no Si
  - (b) that it contains no Al
  - (c) the degree of crystallization of the particles ♣
21. At a low pH, we expect that goethite has a \_\_\_\_\_ charge.
- (a) negative
  - (b) neutral
  - (c) positive ♣
22. The Fe in the sesquioxides is dominantly in the form of
- (a)  $\text{Fe}^{2+}$
  - (b)  $\text{Fe}^{3+}$  ♣
23. Primary minerals in soils are
- (a) mostly found in the silt and sand fraction ♣
  - (b) mostly found in the clay fraction
  - (c) not found in soils, only in rocks

## 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.

- Unsaturated flow \_\_\_\_\_

24.  is faster than saturated flow  F
25.  is driven primarily by the matric potential  T
26.  is stimulated by the osmotic potential  F
27.  depends on the water content of the soil  T

- Soils can retain water because

28.  of adsorptive forces at the solid-liquid interface  T
29.  of capillarity effects  T
30.  the hydraulic conductivity of soils is larger than in groundwater  F
31.  water is attracted to soil minerals because of electrostatic interactions  T

- The Permanent Wilting Point

32.  is the matric potential at  $-0.3$  bars  F
33.  is the matric potential at  $-15$  bars  T
34.  is the potential below which plants usually cannot take up water from the soil anymore  T
35.  is the potential that holds water against the gravity force a few days after a rain or irrigation event  F

- The decrease of the hydraulic conductivity with decreasing soil water content is because

36.  large pores drain first and are not participating in water flow anymore  T
37.  the total volume of conductive area decreases when the soil dries and thus the hydraulic conductivity decreases as well  T
38.  the texture of the soil changes in a drastic manner when the soil is dry  F
39.  the potential gradient decreases when the water content decreases.  F

- Darcy's law states that

40.  the water flow rate is equal to hydraulic conductivity, times cross sectional area, times potential gradient  T
41.  the water flow rate is equal to hydraulic conductivity times potential difference  F
42.  the larger the potential gradient, the larger the water flow rate  T
43.  the water flow rate is equal to hydraulic conductivity times acceleration of gravity  F

- Regarding clay minerals, which of the following statements are true and which are false?

44.  A 2:1 type clay has one octahedral sheet sandwiched between two tetrahedral sheets  T
45.  Of the clay minerals, kaolinite has the largest tendency to expand upon wetting and shrink upon drying  F
46.  Cations used to balance negative charges of clay minerals are usually readily exchanged with other cations  T
47.  At low pH, aluminosilicate clays will carry a net positive charge  F

- Regarding sesquioxides, which of the following statements are true and which are false?

48.  Around pH 7-9, sesquioxides carry very little electric charges  T
49.  Sesquioxides are mainly composed of Si oxides and hydroxides  F
50.  Charges on sesquioxides develop due to protonation/deprotonation of surface hydroxyl groups  T
51.  Sesquioxides have usually a yellow, brown, red, or black color  T

- Ferrihydrite

52.  is an Fe oxide or hydroxide  T
53.  is an Al oxide or hydroxide  F
54.  has a black color  F
55.  contains both  $\text{Fe}^{2+}$  and  $\text{Fe}^{3+}$   F