

WATER FLOW

DARCY'S LAW $q = -K \frac{\Delta H}{\Delta L}$ OR $Q = -KA \frac{\Delta H}{\Delta L}$

AGRY
465

POISEUILLE'S LAW $Q = -\frac{\pi R^4 \rho g \Delta H}{8 \eta L}$

ASSUME $\eta = 1 \times 10^{-2} \frac{g}{cm \cdot sec}$

$\rho = 1 g/cm^3$

$g = 9.8 m/sec^2$

CHEMICAL TRANSPORT

CONVECTION ① $J_c = q C$

DIFFUSION ② $J_d = -D_s \frac{\Delta C}{\Delta X}$ ③ $D_s = D_o \theta_v \{ \}$

DISPERSION ④ $J_h = -D_h \frac{\Delta C}{\Delta X}$ ⑤ $D_h = (\alpha)(\bar{v})$

⑥ $\bar{v} = \frac{q}{\theta_v} = \frac{L}{t_b}$

⑦ $R = 1 + \frac{(BD)(K_d)}{\theta_v}$

\bar{v} = ave. velocity

q = WATER FLUX

θ_v = VOLUMETRIC WATER CONTENT

L = LENGTH

t_b = BREAKTHROUGH TIME

K_d = SORPTION COEFFICIENT

BD = BULK DENSITY

R = RETARDATION COEFFICIENT

GAS DIFFUSION IN SOIL

$q_d = -D_s \frac{\Delta C}{\Delta X}$

$D_s = D(0.66)(f_a)$

Name _____

AGRY 465
Final Exam (150 pts), 10 pages
December 13, 2004

- (4) 1. What are “anaerobic microsites”?
- a. brown mottles in a predominantly gray subsoil
 - b. excess O₂ on aggregate edges caused by rapid drainage
 - c. lack of O₂ in the centers of aggregates even though pores between aggregates are well-aerated
 - d. anaerobic soil conditions throughout the profile due to flooding
- (4) 2. What is the minimum volume of large pores that is considered necessary so that aeration problems will not exist in a soil?
- a. 5%
 - b. 10%
 - c. 15%
 - d. 20%
- (4) 3. Which of these gases are normally in higher concentration in soil air than in the atmosphere? (check all that are correct)
- a. ___ N₂
 - b. ___ O₂
 - c. ___ H₂O vapor
 - d. ___ CO₂
- (4) 4. Why is the diffusion coefficient for a gas in the air, D , different from the diffusion coefficient for gas in soil, D_s ?
- (3) 5. When calculating water potentials in a system at hydraulic equilibrium, the H_{TOTAL} (or Ψ_{total}) is _____ throughout the system.
- (3) 6. When calculating water potentials in a system at hydraulic equilibrium, when the reference level is set at the water table, then the H_{TOTAL} is exactly _____ throughout the system.

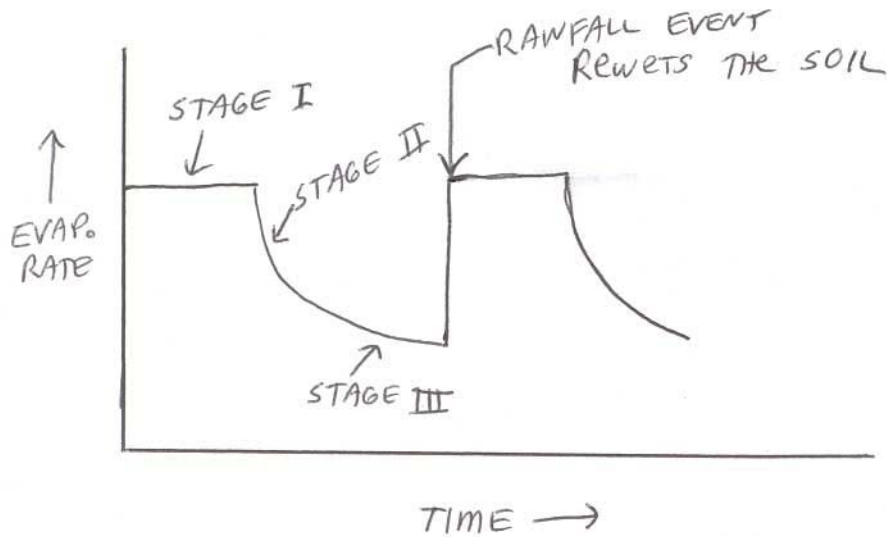
(6) 7. Describe a method of measuring the production of CO₂ (respiration) in a field situation. Draw a labeled sketch to aid your discussion.

(6) 8. In each of the following pairs of conditions, underline the condition that would likely have the highest CO₂ concentration (and lowest O₂ concentration), and briefly describe why.

a) poorly-drained soil / well-drained soil

b) clay soil / sandy soil

c) low fertility cropland / highly productive cropland



(12) 9. Different techniques can be used to change evaporation rates, depending on whether you want to control Stage I or Stage II evaporation (or both).

a) If a straw mulch is placed on top of bare soil, will the Stage I evaporation rate be higher or lower for the mulched soil compared to the bare soil? _____
Briefly explain why.

b) If a soil is tilled and remains very loose in the top 4 inches, will the Stage I evaporation rate be higher or lower for the tilled soil compared to the untilled soil?

_____ Briefly explain why.

c) Will the Stage II evaporation rate be higher or lower for the tilled soil, compared to the untilled soil? _____

Briefly explain why.

- (12) 10. Assume we have a chemical that can be both degraded and sorbed (ie a pesticide). Briefly discuss how each of the following properties of the chemical or the soil affects the time required for the chemical peak to reach groundwater (assuming piston flow) as well as the total mass (“RMF”, or residual mass fraction) of chemical that reaches groundwater, and explain why. When discussing each property, assume all other properties remain unchanged. (NOTE: For each property, you should tell me both how time changes and how mass changes (if at all), and why for both).

a) increasing the K_d or K_{oc} of the chemical

time?

mass?

b) increasing the chemical half-life

time?

mass?

c) increasing the soil organic matter content

time?

mass?

(6) 11. What is preferential flow? What are some of the causes of preferential flow? Why is preferential flow important?

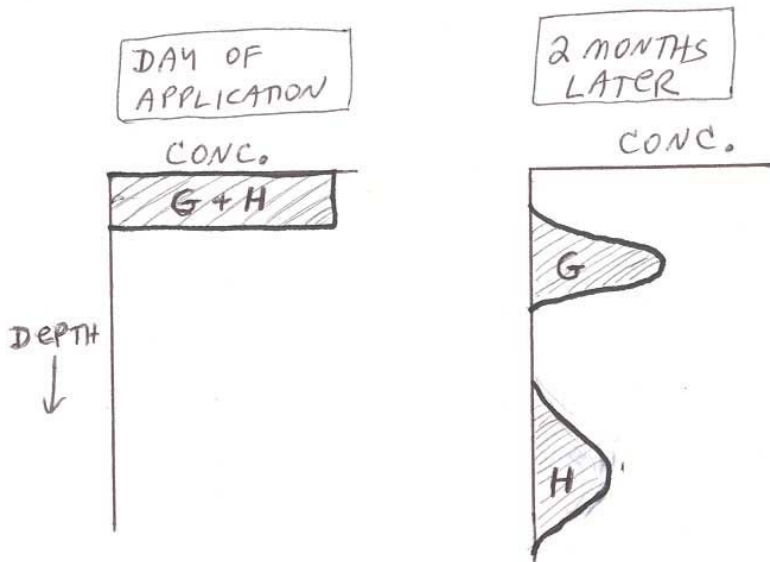
(3) 12. The K in Darcy's Law is for:

- a) Water flux
- b) Hydraulic conductivity
- c) Volumetric water content
- d) Degrees Kelvin

(3) 13. What is "albedo"?

(4) 14. What causes soil albedo to change?

(6) 15. What are the 3 conditions necessary in order for continued evaporation to occur?



- (15) 16. Two chemicals (both non-degradable) were applied and mixed into the top 4 inches of soil. This figure illustrates the relative concentrations of the two chemicals as they move downward through the soil with the percolating water.
- If the two chemicals applied were nitrate and a sorbing pesticide, which chemical (G or H) is the nitrate?
 - Explain convection, diffusion, and dispersion of chemicals in soil. For each process, explain the mechanisms of the process (Equations 1-5 on the front page may refresh your memory on the process, but you do not need to explain all the symbols and terms in the equation)
 - convection -
 - diffusion -
 - dispersion -
 - Which of the three processes are primarily responsible for the bulk movement of chemical downward? (list all that apply)
 - Which of the three processes are primarily responsible for the spreading of the chemical peaks? (list all that apply)

- (15) 17. Given these data for the Clermont silt loam A horizon (you may have been given some unneeded information)

Particle density = 2.65 g/cm^3

Bulk density = 1.40 g/cm^3

$\theta_{v(-50\text{cm})} = 0.395$

$\theta_{v(-0.33 \text{ bar})} = 0.332$

$\theta_{v(-1 \text{ bar})} = 0.225$

$\theta_{v(-15 \text{ bar})} = 0.087$

organic matter = 1.3%

Calculate the following values:

a) Total porosity in cm^3/cm^3

b) Aeration porosity in cm^3/cm^3

c) Storage capacity for plant available water in cm^3/cm^3

d) How much rain (**answer must be in units of cm**) would be needed to bring this soil to saturation, if it is currently at wilting point? Assume the soil is 60 cm deep.

- (15) 18. You are working for a landscaping company that just built a "desert garden" for one of its clients. In their effort to simulate an arid, sodic soil, they mistakenly added too much salt to the sandy loam soil. They also miscalculated and sprayed too much herbicide on the soil.

You decide to remedy the problem by leaching the area with water, under saturated conditions, to flush out the salts and the pesticide into the subsurface drainage system. Calculate the amount of water you will need a) to flush the salts (Cl^-) out of the soil, and b) to flush the pesticide out of the soil. Final answers must be **in units of cm**. Other data you may or may not need are given below.

Data collected

soil depth = 45 cm

B.D. = 1.50 g/cm^3

P.D. = 2.65 g/cm^3

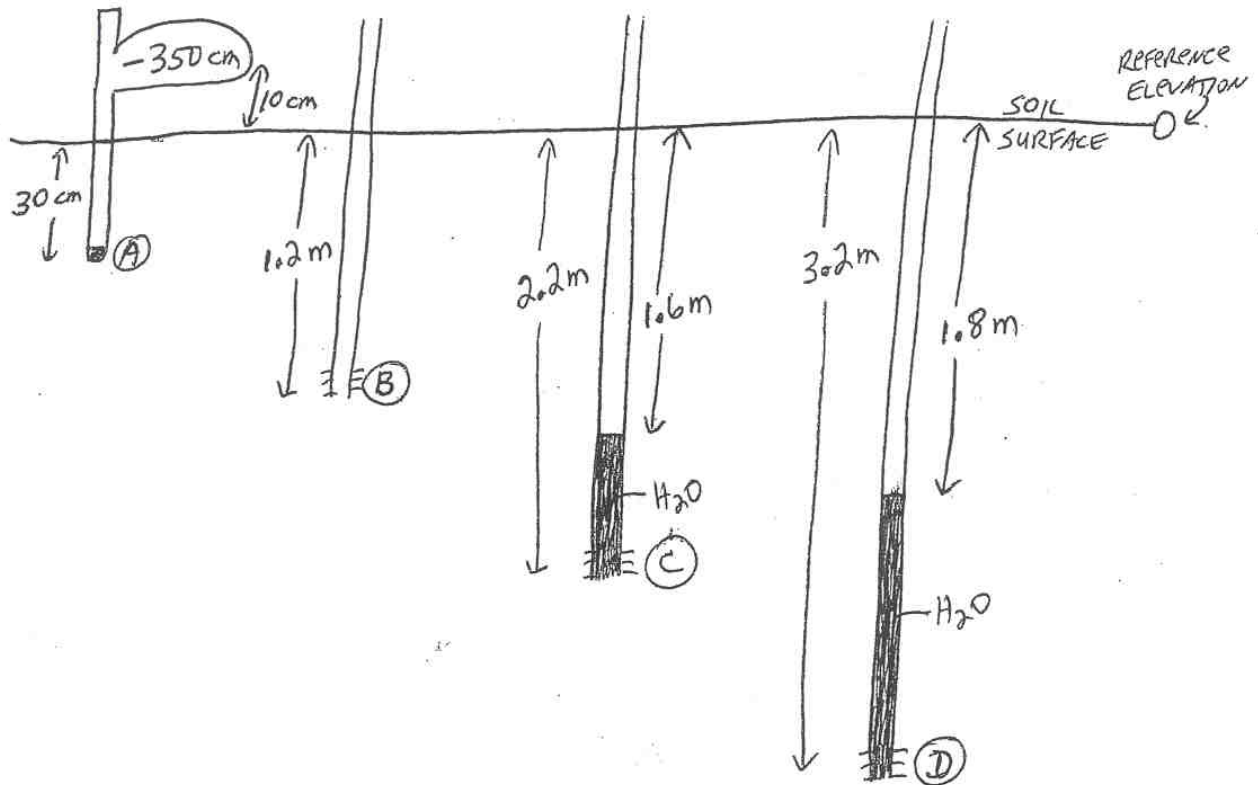
organic C = 0.9%

$K_{\text{sat}} = 3 \text{ cm/hr}$

pesticide $K_d = 0.35 \text{ cm}^3/\text{g}$

soil stays saturated during
leaching

(15) 19.



One tensiometer and three piezometers are installed in the soil as shown.

- Calculate pressure head, elevation head, and total hydraulic head for the soil at points A, B, C, and D. (Note that at one of those points you do not have enough information to calculate pressure head and total hydraulic head).
- What is the "best estimate" of the water table depth in this soil?
- Calculate the water flux (units of cm/day) between the 2.2 m and 3.2 m depths, and tell me whether the water is moving upward or downward. Assume $K_{SAT} = 15$ cm/day.

(10) 20. A chemical plume was detected in shallow groundwater, and it is moving in the direction of a shallow well. Data you may or may not need are given below.

a) When will the plume arrive at the well, assuming piston flow?

b) Calculate the horizontal chemical flux (final units must be $\frac{\text{mg}}{\text{cm}^2 \text{day}}$)

Data

Chemical conc. in plume = 25 mg/liter

θ_v of saturated zone = 0.40

BD of saturated zone = 1.60 g/cm^3

PD of saturated zone = 2.65 g/cm^3

horizontal groundwater flux = 4 cm/day

