INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Date: 24/11/11 (AN) Time: 3 Hrs Full Marks: 50 No. of Students: 18
Autumn Semester Deptt: Agril. and Food Engineering Sub No. AG60063
1st Yr. M. Tech. (ASM) Sub. Name: Soil Systems
Instructions: Answer **ALL** questions.

1. Provide a framework for estimating water retention characteristics from particle size data.

(5)

2. Write Darcy's law for water flow under saturated and unsaturated conditions. Explain the unit gradient flow conditions and give a suitable example for the same.

(5)

3. Describe two major forces (macroscopic) that drive water flow in soil. From fundamental principles of potential, show that the gradient of **total** potential head (and not just any potential head) is the driving force behind water movement in soil.

(5)

4. State the importance of soil temperature for crop growth. List and explain each component of energy balance equations at a bare soil surface.

(5)

5. Describe different processes that influence the status of agrochemicals in soil. Provide quantitative relationships wherever needed.

(5)

6. Urea fertilizer was applied at the rate of 100 kg/ha to a lowland rice crop grown in 1000 m^2 area. Five centimeter of ponded water was steadily maintained at the soil surface at all times. The rice root zone was limited to 40 cm deep. A free water surface was visible right below the root zone (at a depth of 40 cm from soil surface). Assume that the top 40 cm soil is homogenous with a soil bulk density of 1.4 g/cm^3 and saturated hydraulic conductivity of 10 cm/day. It was further observed that the applied urea was instantly hydrolyzed and got uniformly mixed with the ponded water forming soluble ammonium ions. Ammonium ion has a distribution coefficient of 0.1 L/kg. Assuming that soil remains always saturated with water,
   a. Estimate the mean retention time of ammonium within the rice root zone
   b. Estimate the concentration of ammonium ions in ponded water immediately after the urea hydrolysis.

(10)

7. Moist soil is to be packed in a cylindrical core to uniform soil bulk density. Derive a relationship among the mass of wet soil to be taken, soil wetness, and the volume of soil. If the total volume of a cylindrical soil core is 100 cm^3, desired soil wetness is 10% (mass basis), and the desired bulk density is of 1.4 g/cm^3, how much moist soil (with 10% wetness) must be packed to this soil core?

(10)

8. Calculate the volumetric heat capacity of a saturated soil with soil bulk density of 1.46 g/cm^3 and particle density of 2.6 g/cm^3. Assume that 1% of the total solid volume of this soil is organic matter. Repeat your calculation if the organic matter is changed to 5% of the solid volume. Assume that the heat capacity of soil air is negligible. Also, assume that the volumetric heat capacities of mineral phase, organic phase, and water are $2x10^6$, $2.5x10^6$, and $4.2x10^6$ J m^{-3} $^0C^{-1}$, respectively.

(5)