SSC 107
Problem Set 1
Oct 2, 2002
Due: Oct 11, 2002

1) Calculate the pressure caused by a mercury column 30 cm high with a cross-sectional area of 2 cm^2. Give your answer in dynes cm^{-2}, atmospheres, bars, pascals and N m^{-2}. If water is used in the same column instead of mercury, what will be the height of the water column if the same pressure is applied? ($g = 9.8\ m\ s^{-2}$)

2) Both a wet sandy soil sample and a wet peat soil sample weigh 30 g. Both samples are dried at 105 ^oC, after which the respective weights are 25 g and 20 g. Determine the water content on a mass basis for both soils. Both samples are placed back in the 105 ^oC oven for another week. The sandy soil sample still weighs 25 g but the peat soil's weight is now 18 g. Why has the weight of the peat soil decreased?

3) A 20 g oven-dry soil sample, consisting of three soil particle size classes, is dispersed and mixed with water. The soil suspension is placed in a 100-cm tall column and allowed to settle. The coarsest fraction of soil particles reaches the bottom after 1.8 minutes. The second size fraction of soil particles reaches the bottom after 3 hrs, whereas the third size fraction has reached the bottom of the column after 300 hrs. Calculate the diameter of each of the three soil particle size classes. You also determined that the size fraction of the three size fractions weigh 4g, 4g, and 12g, respectively. Determine the soil type using the soil textural triangle. Assume the density of all particles is 2.7 g/cm^3 and the viscosity of water is 0.01 dynes sec cm^{-2}. (Hint: use equation 1.5 on page 3 of Jury et. al., 1991)

4) A surface soil in good condition for plant growth may have the following volume fractions: mineral matter 0.45, organic matter 0.05, soil water 0.3, and soil air 0.2. Assume the density of air is 1.3 kg m^{-3}, the density of minerals is 2,700 kg m^{-3}, the density of organic matter is 1,300 kg m^{-3}, and the density of soil water is 1,000 kg m^{-3}. Consider 1 m^3 of this surface soil.

   a) What is the total volume fraction of the pores in this surface soil?
   b) What is the volume fraction of liquid phase required to saturate the soil?
   c) What is the mass of water required to saturate it?
   d) What is the mass of air in it when completely dry?
   e) What is the mass of the solid phase?
   f) What is the mass of the soil when it is saturated?
   g) What is the mass of wet soil when the volume fraction of liquid phase is only 0.25?

5) A soil core with a volume of 180 cm^3 has a degree of saturation ($S = \theta_v / \theta_{sat}$) of 0.8 (80%). The water content of the core is 0.3 g/g and the particle density is 2.6 g cm^{-3}.

   Calculate:
   a) dry bulk density
   b) volumetric water content
   c) total porosity
   d) air-filled porosity

6) Calculate the height of rise of water in a clean capillary tube of radius R= 0.001 cm. (Surface tension value is 73 dynes cm^{-1} and the contact angle of water to the glass is 10^o)

Extra Credit Problem

Calculate the height of rise of water in a clean capillary tube of radius R= 0.001 cm and height L = 200 cm that is sealed at the top before placing in contact with the free-water reservoir. Assume that the gas pressure inside the capillary is initially atmospheric and obeys Boyle's law. PV=constant. (Surface tension value is 73 dynes cm^{-1} and the angle of contact of water to the glass is 10^o)