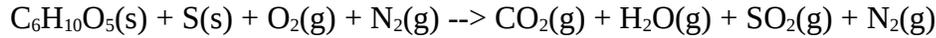


## NAME:

FOR EACH PROBLEM, MAKE (AND STATE) ANY REASONABLE ASSUMPTIONS NECESSARY FOR GETTING A SOLUTION, IN ADDITION TO THOSE GIVEN. BOX YOUR FINAL ANSWERS.

### PROBLEM 1 (20 pts):

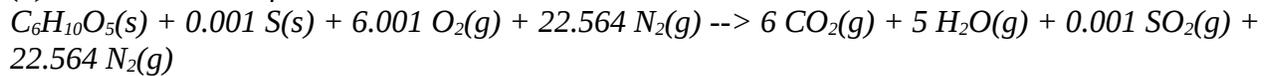
Combustion of straw for fuel may be described by the reaction:



( $\text{C}_6\text{H}_{10}\text{O}_5$  describes the molecular composition of cellulose, the main constituent of straw, whereas a small amount of S is also present in straw.)

- Add the correct stoichiometric coefficients to balance the equation if the ratio of moles of  $\text{N}_2$  to moles of  $\text{O}_2$  on the reactant side is given as 3.76 and the C:S ratio in wood is 6,000.
- Find the mixing ratio (ppmv) of  $\text{SO}_2$  in the exhaust gas stream.
- Find the average molecular weight of the exhaust.
- Find the volume of exhaust gas produced per mole of  $\text{C}_6\text{H}_{10}\text{O}_5$  burned if the exhaust temperature is  $100^\circ\text{C}$  and the pressure is 1 atm.

(a) Assume 1 mole of  $\text{C}_6\text{H}_{10}\text{O}_5$ :



$$(22.564 = 6.001 \cdot 3.76)$$

(b) Assuming ideal gas behavior, this is the same as the mole fraction:  $0.001 / (6 + 5 + 0.001 + 22.564) = 30 \text{ ppmv}$ .

(c) This is the weighted average of the molecular weights of the constituent gases:  $(6 \cdot 44 + 5 \cdot 18 + 0.001 \cdot 64 + 22.564 \cdot 28) / (6 + 5 + 0.001 + 22.564) = 29.37 \text{ g/mol}$ .

(d) We use the ideal gas law, where  $V = nRT/P = 1028 \text{ L}$  ( $n$  is the number of moles of gas produced,  $6 + 5 + 0.001 + 22.564 = 33.565$ ).

### PROBLEM 2 (10 pts):

Briefly describe 3 practices that are recommended to reduce soil erosion on construction sites. For each practice, indicate which term of the USLE is affected.

- Maintain as much vegetation as possible and plant cleared areas as soon as possible (this reduces the vegetation factor C).
- Cover exposed areas with geotextile fabric (erosion control, P).
- Break up slopes with swales along contours to slow storm runoff (erosion control, P).

(Other answers are also possible)

**PROBLEM 3 (20 pts):**

You've obtained the following well water level data

Well	x (m)	y (m)	Ground elevation (m above sea level)	Depth to water table (m)
1	0	0	110	12
2	0	100	100	10
3	200	0	90	8

The local soil is sand with specific gravity of 1.3, porosity of 30%, an organic fraction of 0.2%, and  $K = 20$  m/day.

- Draw a map with the well locations, showing the inferred groundwater flow direction. State this direction as an angle.
- Estimate the hydraulic gradient  $|dh/dL|$ .
- Estimate the groundwater velocity  $|v'|$  using Darcy's law.
- Benzene from an abandoned gas station has infiltrated into the groundwater. Estimate how long it will take to move 1 km in the direction of the groundwater flow.  $K_{oc}$  for benzene is  $28 \text{ L kg}^{-1}$ .

(a) The estimated local water table height is  $h(x, y) = ax + by + c$ , where  $c = 98$ ,  $a = -0.08$ ,  $b = -0.08$ . Assuming north is the  $+y$  direction, the flow direction is therefore 45 degrees east of north.

(b)  $|dh/dL| = \sqrt{a^2 + b^2} = 0.113$ .

(c)  $(K/\eta) * |dh/dL| = 7.5 \text{ m/day}$ .

(d) Using E8.20, the retardation factor  $R = 1 + 1.3 * 28 * 0.002 / 0.3 = 1.2$ , so the benzene velocity will be slowed down by this factor to  $6.1 \text{ m/day}$ , and would take about  $1000 / 6.1 = 165$  days to migrate 1 km.

**PROBLEM 4 (10 pts):**

Think back to the attribute for which your group developed an EIS in the term project.

- Give two ways in which a new building project, such as the expansion of City College, could negatively affect your attribute.
- Give two ways in which negative impacts to your attribute could be mitigated through sustainable development or LEED practices.

*This will depend on your attribute, but any reasonable answers that are supported by the textbook or your report are acceptable.*

**PROBLEM 5 (20 pts):**

(a) A river has a flow rate of  $1 \text{ m}^3/\text{s}$ ,  $T = 10 \text{ C}$ ,  $v = 1 \text{ m/s}$ . If at  $x = 0 \text{ km}$ ,  $L = 10 \text{ mg/L}$ ,  $\text{DO} = 10 \text{ mg/L}$ , and there are no intervening sources of BOD, estimate its DO level at  $x = 100 \text{ km}$ . Assume that  $k_d = 0.2 \text{ d}^{-1}$ ,  $k_r = 0.5 \text{ d}^{-1}$ .

(b) How would your answer change if  $k_d$  was higher than given above, and why? (No calculations necessary for this part.)

*(a) (16 pts) Use Eqs. 8.17 and 8.18 with  $t = x / v = (100 \text{ km}) / (86.4 \text{ km/day}) = 1.2 \text{ days}$ . From T8.7,  $\text{DO}_{\text{sat}} = 11.29 \text{ mg/L}$ , so  $\text{DO} = 1.29 \text{ mg/L}$ . The result is  $\text{BOD}(100 \text{ km}) = 7.9 \text{ mg/L}$ ,  $\text{DO}(100 \text{ km}) = 9.0 \text{ mg/L}$ .*

*(b) (4 pts) With higher  $k_d$ , deoxygenation would happen faster, which would reduce BOD for all positive  $x$ . DO would be reduced for smaller  $x$  (roughly, less than  $t/v$ ) because more oxygen is being used up more quickly, but DO would increase for larger  $x$  because less oxygen is being used up by respiration at later times, since more of the BOD is gone.*

**PROBLEM 6 (20 pts):**

(a) Estimate the amount of water infiltrated into  $10 \text{ m}^2$  of Leefield loamy sand during a heavy rainstorm that lasts 2 hours using Horton's model. (b) Estimate the maximum, minimum, and mean infiltration velocity over the rainstorm.

*From T8.2,  $f_c = 4.39 \text{ cm/h}$ ,  $f_0 = 28.80 \text{ cm/h}$ ,  $k = 7.70 \text{ cm/h}$ .*

*(a) Using Eq. 8.4 with  $XY = 10 \text{ m}^2$  and  $T = 2 \text{ h}$ ,  $Q(T) \cdot T = 1195 \text{ L}$ .*

*(b) Maximum velocity is the initial velocity, which is equal to  $f_0 = 28.80 \text{ cm/h}$ . Minimum velocity is at  $t = T$ , when  $f(t) = 4.39 \text{ cm/h}$  (very close to  $f_c$ ). Mean velocity can be computed as  $Q/(XY) = 5.98 \text{ cm/h}$ .*