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:

$C_6H_{10}O_5(s) + S(s) + O_2(g) + N_2(g) \text{ --> } CO_2(g) + H_2O(g) + SO_2(g) + N_2(g)$

($C_6H_{10}O_5$ describes the molecular composition of cellulose, the main constituent of straw, whereas a small amount of S is also present in straw.)

(a) Add the correct stoichiometric coefficients to balance the equation if the ratio of moles of N_2 to moles of O_2 on the reactant side is given as 3.76 and the C:S ratio in wood is 6,000.

(b) Find the mixing ratio (ppmv) of SO_2 in the exhaust gas stream.

(c) Find the average molecular weight of the exhaust.

(d) Find the volume of exhaust gas produced per mole of $C_6H_{10}O_5$ burned if the exhaust temperature is 100 °C and the pressure is 1 atm.

(a) Assume 1 mole of $C_6H_{10}O_5$:

$C_6H_{10}O_5(s) + 0.001\ S(s) + 6.001\ O_2(g) + 22.564\ N_2(g) \text{ --> } 6\ CO_2(g) + 5\ H_2O(g) + 0.001\ SO_2(g) + 22.564\ N_2(g)$

*(22.564 = 6.001*3.76)*

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

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

(d) We use the ideal gas law, where V = nRT/P = 1028 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.

(a) Maintain as much vegetation as possible and plant cleared areas as soon as possible (this reduces the vegetation factor C).

(b) Cover exposed areas with geotextile fabric (erosion control, P).

(c) 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.

(a) Draw a map with the well locations, showing the inferred groundwater flow direction. State this direction as an angle.
(b) Estimate the hydraulic gradient |dh/dL|.
(c) Estimate the groundwater velocity |v'| using Darcy's law.
(d) 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 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 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 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.
(a) Give two ways in which a new building project, such as the expansion of City College, could negatively affect your attribute.
(b) 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 m^3/s, T = 10 C, v = 1 m/s. If at x = 0 km, L = 10 mg/L, DO = 10 mg/L, and there are no intervening sources of BOD, estimate its DO level at x = 100 km. Assume that $k_d = 0.2\ d^{-1}$, $k_r = 0.5\ d^{-1}$.
(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 km) / (86.4 km/day) = 1.2 days. From T8.7, DOsat = 11.29 mg/L, so D0 = 1.29 mg/L. The result is BOD(100 km) = 7.9 mg/L, DO(100 km) = 9.0 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_c/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 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, fc = 4.39 cm/h, f0 = 28.80 cm/h, k = 7.70 cm/h.
*(a) Using Eq. 8.4 with XY = 10 m^2 and T = 2 h, Q(T)*T = 1195 L.*
(b) Maximum velocity is the initial velocity, which is equal to f0 = 28.80 cm/h. Minimum velocity is at t = T, when f(t) = 4.39 cm/h (very close to fc). Mean velocity can be computed as Q/(XY) = 5.98 cm/h.