Fate and Transport First Exam – 2006 (100/110)

Closed Book Section (60):

Questions 1-6 refer to the gasoline spill picture and the potential answers A - H below.

A. advection

B. vapor pressure

C. aqueous solubility

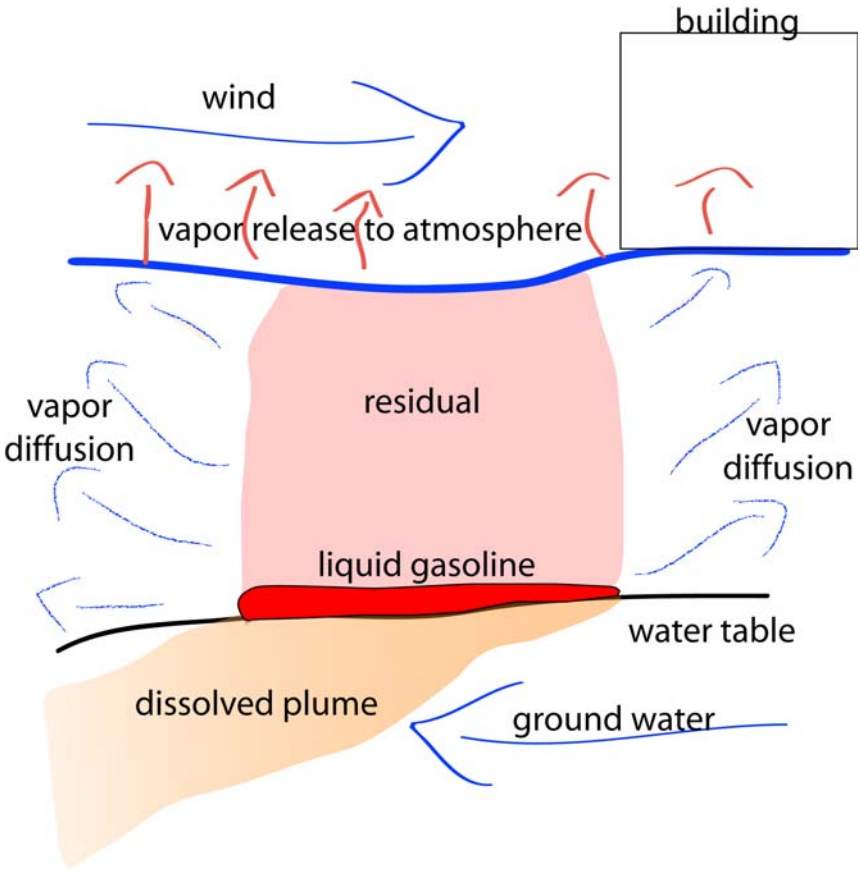
D. henry's law constant

E.adsorption

F. diffusion and/or dispersion

G. density

H. surface tension



1. (4) The location of the NAPL layer in the figure is most closely related to _____.
2. (4) The amount of residual gasoline is most closely related to _____
3. (4) The movement of vapor by the wind is an example of _____.
4. (4) The concentration in the dissolved plume is most closely related to _____.
5. (4) Transport of the dissolved plume in ground-water is an example of _____
6. (4) The boundary condition for vapor transport from the region with residual gasoline is most closely related to _____

7. (4) T / F The open book portion of this examination will ask you to solve a problem dealing with vapor concentrations in this building.

8. (8) Derive equation 2 from equation one. Define all terms including SI units.

$$\frac{dC}{dt} = \frac{\sum_i I}{V} - \frac{\sum_j O}{V} \pm \frac{\sum_k R}{V} \quad (1)$$

$$\frac{dM}{dt} = \sum_i I - \sum_j O \pm \sum_k R \quad (2)$$

Table 0-1. Tracer diffusion coefficients at infinite dilution in water. (Li and Gregory, 1974)

Cations	D (10^{-10} m^2/s)				Anions	D (10^{-10} m^2/s)		
	0°C	18°C	25°C			0°C	18°C	25°C
H^+	56.1	81.7	93.1		OH^-	25.6	44.9	52.7
Na^+	6.27	11.3	13.3		F^-	--	12.1	14.6
K^+	9.86	16.7	19.6		Cl^-	10.1	17.1	20.3
NH_4^+	9.8	16.8	19.8		Br^-	10.5	17.6	20.1
Ca^{2+}	3.73	6.73	7.93		I^-	10.3	17.2	20
Sr^{2+}	3.72	6.7	7.94		IO_3^-	5.05	8.79	10.6
Co^{2+}	3.41	5.72	6.99		SO_4^{2-}	5	8.9	10.7
Cd^{2+}	3.41	6.03	7.17		NO^{3-}	9.78	16.1	19

9. (4) The two factors most strongly influencing aqueous diffusion coefficients in pure water are _____

10. (4) This equation represents:

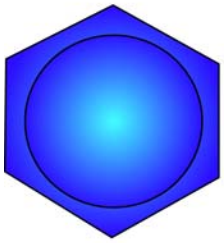
$$C = \frac{M}{2\sqrt{\pi D_e t}} \exp\left(\frac{-x^2}{4D_e t}\right) \quad (3)$$

a) diffusion in the vapor phase
b) diffusion in the aqueous phase
c) two dimensional diffusion
d) diffusion in an infinite medium

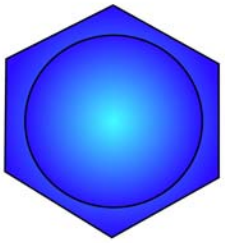
11. (8) Label all the terms in the equation with SI units.

12. (8) Complete the figures for each compound and fill in the blanks.

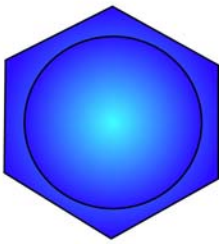
Aromatic



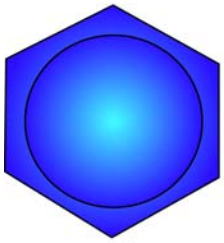
benzene



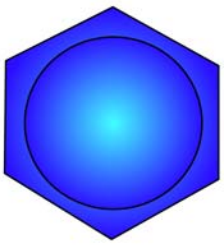
toluene



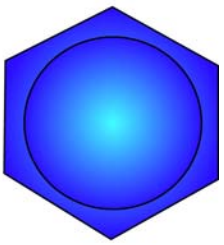
o-xylene



m-xylene

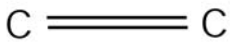


p-xylene



phenol

Aliphatic



trichloroethylene
or _____

tetrachloroethylene
or _____
or _____
or _____

Open Book Section (50)

Some people are lucky, and then there's the rest of us. Why is your new house located so close to the prior gasoline spill from the closed book portion of the exam? You've talked to the owners and they offer only denial, denial, denial. Sounds like certain (all?) politicians and/or certain local industry. Let's focus on benzene, a nice, mildly toxic and very mobile compound contained in gasoline.

Prior to purchasing the house you noticed that the owner always left the windows open, even though it was cool outdoors. Perhaps that kept the concentration below 5 mg/m^3, the concentration where most humans can smell benzene. According to EPA the safe level is < 1.7 mg/m^3.

13. (15) What is the vapor pressure, molecular weight, Henry's Law constant, and aqueous solubility of benzene? At 25 C what is the concentration of benzene in equilibrium with the atmosphere in units of kg/cubic meter?

14. (20) Benzene enters your new house through the floor by diffusion from the ground at a rate of 0.01 kg/s and the outdoor concentration of benzene in the air is 0.5 mg/m^3. With the windows closed the house leaks air at a rate of 0.02 m^3/s. Find the steady state concentration of benzene in your house. Will you smell the benzene? Is it present at toxic levels? What would happen if you weatherproofed the house by caulking the windows and putting new seals around the doors? Show the control volume, the simplification of the control volume equation, and all your work.

15. (15) The concentration of benzene just below the bottom of the concrete floor slab in the house is 0.1 kg/m^3. Today, the indoor concentration of benzene is 0.00123 kg/m^3 The effective diffusion coefficient is 9.3-7 m^2/s. The porosity is 0.05, and the permeability is $10^{-14} m^2$. Find the steady state diffusion rate through the 0.1 m thick slab in units of $kg/m^2/s$.