

# Fate & Transport Solution Set #5

CE/ESR 479/579

1. (1-14)

$$C_{\text{fat}} = 0.1 \text{ ppm}$$

$$C_{\text{oct}}/C_w = C_{\text{fat}}/C_w = 10^{1.96}$$

$$C_w = C_{\text{fat}}/K_{\text{ow}} = (0.1 \text{ ppm}) / 10^{1.96} = \underline{\underline{0.001 \text{ ppm (mg/L)}}}$$

2. (1-15)

$$V_w = 250 \text{ mL}$$

$$V_{\text{oct}} = 200 \text{ mL}$$

$$V_a = 50 \text{ mL}$$

$$M_w = 5 \text{ mg}$$

$$C_w = 5 \text{ mg}/0.25 \text{ L} = 20 \text{ mg/L}$$

Sol'y of o-xylene = 175 mg/L >> 20 mg/L so all of the xylene is dissolved: no free product

## AIR-WATER

$$C_a = K_H C_w$$

$$M_a = K_H C_w V_a = (0.22)(20 \text{ mg/L})(0.05 \text{ L}) = 0.22 \text{ mg}$$

## OCTANOL-WATER

$$C_{\text{oct}} = K_{\text{ow}} C_w$$

$$M_{\text{oct}} = K_{\text{ow}} C_w V = 10^{3.12}(20 \text{ mg/L})(0.20 \text{ L}) = 5,300 \text{ mg}$$

So, virtually all of the xylene is in the octanol phase.

3. (2-4)

$$C_s = f_{\text{oc}} K_{\text{oc}} C_w \quad (\text{Units for } C_s \text{ are mg/kg: mg contaminant per kg suspended solids})$$

$$f_{\text{oc}} = 1.0$$

$$\text{Mass of contaminant on solids} = M_s = (1.0)(K_{\text{oc}} C_w)(\text{mass of susp. solids})$$

$$C_{\text{filt}} = C_w$$

$$C_{\text{unfilt}} = (\text{mass dissolved} + \text{mass on solids}) / \text{volume of solution}$$

$$= C_w + (\text{mass on particles}) / \text{volume of solution}$$

$$= C_w + (K_{\text{oc}} C_w M_{\text{ss}}) / V = C_w(1 + K_{\text{oc}} \text{TSS})$$

$$= C_w + (4000 \text{ L/kg})(20 \text{ mg/L})(10^{-6} \text{ kg/mg}) = \underline{\underline{1.08 C_w}}$$


So, even though  $K_{\text{oc}}$  is quite large at 4000 L/kg, the TSS is modest at 20 mg/L so the effect of filtration is quite small, only an 8% difference.

4. (2-6) Pentane: MW 21.15  
 Octane: MW 114.2

$k_p = 1 \text{ cm.h}$  (given)

But need to convert to reaeration constant form to get first order loss of conc.

$$C_p(t) = C_{op} \exp(-k_r t) \quad \text{Where } k_r = k_{rp} / d = (1 \text{ cm/h}) / (400 \text{ cm}) = \underline{0.0025 \text{ h}^{-1}}$$

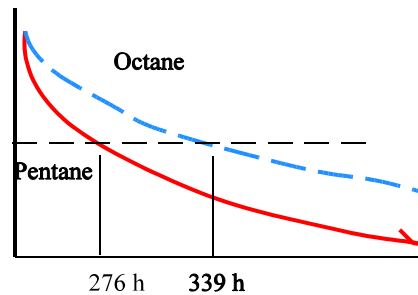
Get  $k_r$  for octanol by Graham's Law:  $k_{ro} = k_{rp} [MW_p/MW_o]^{1/2} = \underline{0.002 \text{ h}^{-1}}$  

I'll just roughly sketch plots using the two half-lives, where  $\tau_{1/2} = 0.69 / k_r$

Pentane:  $\tau_{1/2} = 276 \text{ hr}$

Octane:  $\tau_{1/2} = 339 \text{ hr}$

a), b)



c) Gasoline gradually loses relatively more of the low molecular weight fraction (like pentane) relative to the slower volatilizing higher MW fractions (like octane). This is a well know phenomena in oil and gasoline spills.

d) Biodegradation and adsorption are also likely important removal mechanisms for hydrocarbons.

5. (2-9) a, b)

$m' = 10 \text{ mg/min}$

$Q = 10 \text{ L/min}$

$$C_{max} = m' / Q = (10 \text{ mg/min}) / (10 \text{ L/min}) = 1 \text{ mg/L} \ll \text{sol'y} = 950 \text{ mg/L}$$

Therefore all dissolves, no NAPL accumulates, and  $C_{max}$  is as above (regulated by drip rate and not by solubility.)

c) Need piston velocity (not aeration coeff) to get flux:

$$k = k_r d = (0.4 \text{ h}^{-1})(0.25 \text{ m}) = 0.1 \text{ m/h}$$

$$J = k C_{max} = (0.1 \text{ m/h})(1 \text{ g/m}^3) = \underline{\underline{0.1 \text{ g/m}^3\text{-h}}}$$