PLEASE WORK UP YOUR OWN ANSWERS BEFORE CHECKING HERE!

(1) (4) $V = 2 \times 10^5\ m^3$

$Q_{in} = 10^5\ m^3/y$

$C_{IN} = 7\ mg/L$

$Q_{out} = 9 \times 10^4\ m^3$

$C_{out} = 6.5\ mg/L$

$\dot{m}_{in}^{DOM} - \dot{m}_{out}^{DOM}$ = source/sink of DOM

$$m_{in} - m_{out} = C_{in}Q_{in} - C_{out}Q_{out}$$

$$= \left(7\ \frac{mg}{L}\right)\left(\frac{1000L}{m^3}\right)\left(10^5\ \frac{m^3}{y}\right)\left(\frac{1\ y}{365\ d}\right) - \left(\frac{6.5mg}{L}\right)\left(\frac{10^3 L}{m^3}\right)\left(9\times10^4\ \frac{m^3}{y}\right)\left(\frac{1y}{365\ d}\right)$$

$$= 1.9 \times 10^6\ \frac{mg}{d} - 1.6 \times 10^6\ \frac{mg}{d} = 0.3 \times 10^6\ \frac{mg}{d} \left(= 0.3\ \frac{kg}{d}\right)$$

Answer asked for in units of mass/m³·day

$$\frac{\dot{m}^{sink}}{V_T} = \frac{0.3 \times 10^6\ mg/d}{2 \times 10^5\ m^3} = \boxed{1.6\ \frac{mg}{m^3 d}}$$ ANS

(2) 10 ci = 10 curies of Cs-137 (The curie is a unit of radioactivity)

Residence time in atmosphere = 2 y

How much decays away in 2 y?

$$C_{2y} = C_0 e^{-kt} \qquad k = \frac{0.69}{\tau_{1/2}} = \frac{0.69}{1.1E4\ d} = 6.3 \times 10^{-5}\ d^{-1}$$

$$C_{2y} = [10\ ci]\, e^{-(6.3\times10^{-5}\ d^{-1})(2\times 365\ d)} = (10\ ci)(0.955)$$

$$\boxed{C_{2y} = 9.5\ ci}$$ ANS

I.e. during the average 2 years the Cs-137 spends in the atmosphere, it decays by ~5%, so about 95% returns to earth surface.

(3) (21) Formic Acid (HCOOH)

$$HCOOH \rightleftarrows HCOO^- + H^+ \; ; \; K_a = 1.8 \times 10^{-4} \frac{mol}{L}$$

$(\log K_a = -3.75)$ GIVEN

If pH is "entirely controlled by the ionization to yield H^+ & $HCOO^-$" (GIVEN)

Then $[H^+] = [HCOO^-]$ ← Formate is ONLY source of protons

Mass Action Equ: $\frac{[HCOO^-][H^+]}{[HCOOH]} = \frac{[H^+]^2}{[HCOOH]}$ ← from above assumption

$= 10^{-3.75}$ (K_a)

$HCOOH_{TOTAL} = 0.08 \frac{mol}{L} = [HCOOH] + [HCOO^-]$ ↖ 2 possible species

Now unless pH is really low, it's likely that

$[H^+] = [HCOO^-] \ll [HCOOH] \approx 0.08M$

↑ THIS USUALLY SMALL — Hence this must be true — ↑ THIS PRETTY BIG

∴ $[HCOOH] \approx$ Total HCOOH $= 0.08M$ (will double check later)

$$\frac{[H^+]^2}{[HCOOH]} = \frac{[H^+]^2}{0.08M} = 10^{-3.75} \Rightarrow [H^+] = \sqrt{(0.08)(1.8 \times 10^{-4})}$$

$$= \sqrt{1.4 \times 10^{-5}} = 3.8 \times 10^{-3} M$$

$$pH = -\log[3.8 \times 10^{-3} M] = \boxed{2.4}$$

CHECK ASSUMPTION: $\frac{[HCOO^-]}{[HCOOH]} = \frac{10^{-3.75}}{10^{-2.4}} = 10^{-1.3} = 0.047$

So formate only ~5% of total formic acid and our assumption was <u>OK</u>

<u>NOTE</u>: If you don't figure out all the assumptions yourself, don't panic about exam. <u>BUT</u> do try to learn a few things...

(4) $f_{oc} = 0.05$ Naphthalene $K_{ow} = 10^{3.36}$ (Table 1-3)
← PAH

Table 3-5, 3rd Eqn should work for a PAH:

$$\log K_{oc} = 1.00 \log K_{ow} - 0.21$$

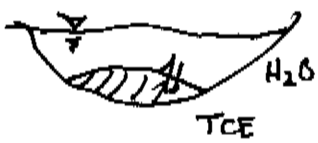
$$\log K_{oc} = 3.36 - 0.21 = 3.15$$

$$K_p = f_{oc} K_{oc} = (0.05)(10^{3.15}) \cong 71 \frac{mL}{g}$$ (UNITS INDICATED BY TEXT & CLASS NOTES)

$K_p = \frac{C_s}{C_w}$ $C_s = 1.0$ mg/kg (GIVEN)

$$C_w = \frac{C_s}{K_p} = \frac{1.0 \text{ mg/kg}}{71 \text{ mL/g}} \cdot \frac{1 \text{ kg}}{10^3 \text{ g}} = 1.4 \times 10^{-5} \frac{mg}{mL} = 1.4 \times 10^{-5} \frac{g}{L}$$

$= 14 \frac{mg}{L}$ ANS

(5) 

MAX Conc. is SOLUBILITY LIMIT

Sol'y TCE = **1,000 mg/L** (Table 1-3) ANS

(6) Lake: $A = 1.5$ hA $= 1.5 \times 10^4 m^2$
$\bar{D} = 2m$
$V = D \cdot A = 3. \times 10^4 m^3$
$Q_{in} = 10$ L/s
} GIVEN

Net Rain Input 10 mm/day over area of $1.5 \times 10^4 m^2$

$$Q_{IN}^{RAIN} = \frac{(0.01 \text{ m/d})(1.5 \times 10^4 m^2)(1000 \text{ L/m}^3)}{86{,}400 \text{ s/d}} = 1.7 \text{ L/s}$$

Total Outflow $= Q_{IN} + Q_{IN}^{RAIN} = (10 + 1.7) = 11.7$ L/s

$$\dot{m}_{IN}^{TCE} = C_{in}^{TCE} Q_{in} = (1000 \text{ mg/L})(10 \text{ L/s}) = 10{,}000 \text{ mg/s}$$

$$\dot{m}_{OUT}^{TCE} = C_{out}^{TCE} Q_{out} = (250 \text{ mg/L})(11.7 \text{ L/s}) = 2{,}900 \text{ mg/s}$$

$\Delta \dot{m}$ = LOSS TO VOLATILIZATION $= 10{,}000 \frac{mg}{s} - 2{,}900 \frac{mg}{s} = 7100 \frac{mg}{s} =$ **$7.1 \frac{g}{s}$** ANS

~ 70% loss to VOLATILIZATION