TOPIC: SOLUTION SET: Midterm 1

DATE:

FILE UNDER: ESR 320 Fall '08

1

$p_0 = 765$ mm-Hg $\quad h_0 = 50$ m

ASSUME
$T = 25°$
$T = 298$ K

At $h = 310$ $\quad p = ?$

$$p = p_0 e^{-\left[\frac{MW \cdot g}{RT}\right]\Delta h}$$

$$p = (765 \text{ mm-Hg}) \exp -\left\{\left(\frac{MW \cdot g}{RT}\right)(310 - 50 \text{ m})\right\}$$

↑

UNITS & VALUES:

$MW = 28.6 \text{ g} \cdot \text{mol}^{-1} = 0.0286 \frac{\text{kg}}{\text{mol}}$

$g = 9.8 \text{ m s}^{-2}$

$T = 298$ K

Want R in units of kg, mol, m, K, etc

$Pa = 1 \text{ N m}^{-2} = 1 \text{ kg m s}^{-2} \text{ m}^{-2} = 1 \text{ kg s}^{-2} \text{ m}^{-1}$

$R = 8.314 \text{ m}^3 \cdot Pa/\text{mol} \cdot K = 8.314 \frac{\text{m}^2 \text{ kg s}^{-2}}{\text{mol K}}$

$$\therefore \frac{MW \cdot g}{RT} = \frac{(0.0286 \text{ kg mol}^{-1})(9.8 \text{ m s}^{-2})}{(8.314 \text{ m}^2 \text{ kg s}^{-1} \text{ mol}^{-1} \text{ K}^{-1})(298 \text{ K})}$$

$$= 1.13 \times 10^{-4} \text{ m}^{-1}$$

$$\therefore p = (765 \text{ mm-Hg}) \exp -\left\{(1.13 \times 10^{-4} \text{ m}^{-1})(260 \text{ m})\right\}$$

$$= 765 e^{-2.9 \times 10^{-2}}$$

$$= 765(0.971) = \boxed{743 \text{ mm-Hg}}$$

2. Use $pV = nRT$

Notice nRT all CONSTANT (T assumed)

$\therefore$ pV = constant or can say as p_1 changes to p_2:

$$p_1 V_1 = p_2 V_2 = \text{constant}$$

↑ If p goes down ↑ V must go up

$$p_1 V_1 = p_2 V_2$$

$$V_2 = V_1 \frac{p_1}{p_2}$$

p_1 = sealevel pressure
p_2 = p @ 6000 ft
V_1 = 1.0 L
V_2 = Vol. @ 6000 ft

$$p_2 = p_1 e^{-k\Delta h}$$

$$\therefore \frac{p_2}{p_1} = e^{-k\Delta h} \text{ and } \frac{p_1}{p_2} = \frac{1}{e^{-k\Delta h}} = e^{+k\Delta h}$$

$$V_2 = V_1 e^{+k\Delta h}$$

$$\Delta h = (6000\text{ ft})(0.305\ \tfrac{\text{m}}{\text{ft}}) = 1829\text{ m}$$

Use $k = 1.13 \times 10^{-4}\ \text{m}^{-1}$ from Problem #1

$$V_2 = (1.0\text{ L})\, e^{(+1.13 \times 10^{-4}\ \text{m}^{-1})(1829\text{ m})}$$

$$= (1.0\text{ L})(1.23)$$

$$\boxed{V_2 = 1.23\text{ L @ 6000 ft}}$$

TOPIC: | DATE:
FILE UNDER: | PAGE:

3. D.A.L. = $-9.8\ ^\circ C / 1000\ m$

$$\Delta h = (4000\ ft)(0.305\ m\ ft^{-1}) = 1220\ m$$

$$\Delta T = (-9.8^\circ C/1000\ m)(1.220 \times 1000\ m)$$

$$= -12.0\ ^\circ C$$

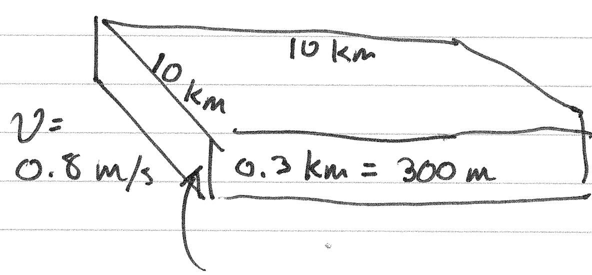
$$^\circ F = \frac{9}{5}(^\circ C) + 32$$ ← But 32 drops out for <u>change</u> in T

$$\Delta T = \frac{9}{5}(12^\circ C)$$

$$= -21.6\ ^\circ F$$

$$T_{4000\ ft} = 70^\circ F - 21.6 = \boxed{48^\circ F}$$ (Brrr....)

4.



WANT "C" (ave. conc.)

$$A_{xs} = (10\ km)(1000\ m/km)(300\ m) = 3 \times 10^6\ m^2$$

INPUT = $\dot{m}$ = 1 tonne/h = $1000\ kg\ h^{-1}$

$$\dot{m} = Q\,C$$

$\dot{m}$ ↑ KNOWN; Q ↑ CAN CALC.; C ↖ DESIRED VALUE (unknown)

$$C = \frac{\dot{m}}{Q} = \frac{\dot{m}}{v A_{xs}} = \frac{1000\ kg\ h^{-1} / 3600\ s\ h^{-1}}{(0.8\ m s^{-1})(3 \times 10^6\ m^2)}$$

$$= 1.16 \times 10^{-7} \frac{kg}{m^3} \qquad = 4.2 \times 10^{-4}\ kg$$

$$\boxed{= 1.2 \times 10^{-4}\ g/m^3}$$

5. $Q = VA_{xs} = (0.8\ m\,s^{-1})(1.5\ m^2) = 1.2\ m^3 s^{-1}$

$\dot{m} = QC$ $\quad = (1.2\ m^3 s^{-1})(86{,}400\ s\,d^{-1}) = 103{,}680\ \frac{m^3}{d}$

a.

CHEMICAL	CONC. (C) + CONVERSIONS	$\dot{m} = QC$	
Atrazine	0.55 ppb = 55 $\mu g/L$ = 55 mg/m^3 = 0.055 g/m^3	× $(103{,}680\ \frac{m^3}{d})$	= **5700 g/d**
P	15 $\mu g\,L^{-1}$ = 15 mg/m^3 = 0.015 g/m^3	× $(103{,}680\ \frac{m^3}{d})$	= **1560 g/d**
N	1.2 mg/L = 1.2 g/m^3	× $(103{,}600\ \frac{m^3}{d})$	= **124,000 g/d**

(a) ANSWERS ↑

b. $A_s = 3.5\ ha = 35{,}000\ m^2$

FLUX = (mass flow)/(Area) $= \frac{\dot{m}}{A_s} = \cdots$

Atrazine: $\frac{5700\ g/d}{35{,}000\ m^2} = 0.16\ \frac{g}{m^2 d} = 160\ \frac{mg}{m^2 d}$

P : $\frac{1560\ g/d}{35{,}000\ m^2} = 0.044\ \frac{g}{m^2 d} = 44\ \frac{mg}{m^2 d}$

N : $\frac{124{,}000\ g/d}{35{,}000\ m^2} = 3.6\ \frac{g}{m^2 d} = 3{,}600\ \frac{mg}{m^2 d}$

ANS.

↑ EITHER LOOKS FINE ↑