

$$V = 2 \times 10^{-3} \text{ m} \times 1.0 \times 10^7 \text{ km}^2 \times \left( \frac{10^3 \text{ m}}{\text{km}} \right)^2$$

$$= 2.0 \times 10^{10} \text{ m}^3$$

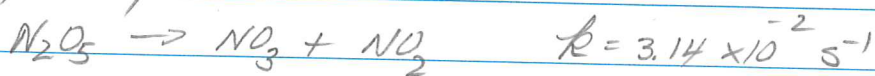
$$= 2.0 \times 10^{13} \text{ L} \quad \left( \because \frac{10^3 \text{ L}}{\text{m}^3} \right)$$

$$\therefore [\text{H}^+] = \frac{3.3 \times 10^9 \text{ mols}}{2.0 \times 10^{13} \text{ L}} = 1.65 \times 10^{-4} \text{ M}$$

$$\therefore \text{pH} = 3.8$$

b) some  $\text{HNO}_3$  &  $\text{H}_2\text{SO}_4$  exported  
 some dry deposition (eg.  $(\text{NH}_4)_2\text{SO}_4$ )  
 some in complete oxidation of  $\text{SO}_2$

2/ (Chap 5, Q8)

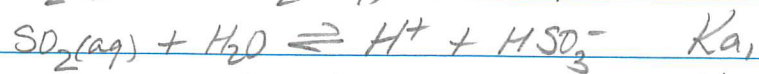
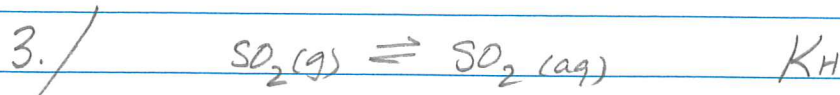


first order kinetics, conc  $\leftrightarrow$  time  $\therefore$  integrated rate law

$$\ln \left( \frac{[\text{A}]_t}{[\text{A}]_0} \right) = -kt$$

$$\therefore t = \ln \left( \frac{[\text{A}]_t}{[\text{A}]_0} \right) / -k = \ln \left( \frac{1.0}{3.6} \right) / -3.14 \times 10^{-2} \text{ s}^{-1}$$

$$= 41 \text{ sec.}$$



$$[\text{SO}_2(aq)]_T = [\text{SO}_2(aq)] + [\text{HSO}_3^-(aq)] + [\text{SO}_3^{2-}(aq)]$$

$$K_H = \frac{[\text{SO}_2(aq)]}{P_{\text{SO}_2}}$$

$$K_{a1} = \frac{[\text{H}^+][\text{HSO}_3^-]}{[\text{SO}_2(aq)]}$$

$$\therefore [\text{SO}_2(aq)] = K_H P_{\text{SO}_2}$$

$$\therefore [\text{HSO}_3^-] = \frac{K_{a1} [\text{SO}_2(aq)]}{[\text{H}^+]}$$

$$\therefore [\text{HSO}_3^-] = \frac{K_{a1} K_H P_{\text{SO}_2}}{[\text{H}^+]}$$

and  $K_{a2} = \frac{[\text{H}^+][\text{SO}_3^{2-}]}{[\text{HSO}_3^-]}$

$$\therefore [\text{SO}_3^{2-}] = \frac{K_{a2} [\text{HSO}_3^-]}{[\text{H}^+]}$$

$$= \frac{K_{a1} K_{a2} K_H P_{\text{SO}_2}}{[\text{H}^+]^2}$$

Therefore,

$$[\text{SO}_2(aq)]_T = K_H P_{\text{SO}_2} \left( 1 + \frac{K_{a1}}{[\text{H}^+]} + \frac{K_{a1} K_{a2}}{[\text{H}^+]^2} \right)$$

(Similar to Chap. 5, Q12)

$$4. / \quad 1.0 \times 10^6 \text{ L day}^{-1} \times 0.80 \text{ kg L}^{-1} = 0.8 \times 10^6 \text{ kg day}^{-1}$$

$$\text{C}_{15}\text{H}_{32} \Rightarrow \text{MW} = 212 \text{ g mol}^{-1}$$

$$\therefore 0.8 \times 10^6 \text{ kg} \times \frac{1 \text{ mol}}{0.212 \text{ kg}} = 3.77 \times 10^6 \text{ mol/day}$$



Stack contains  $\text{CO}_2(\text{g})$ ,  $\text{H}_2\text{O}(\text{g})$  and  $\text{N}_2(\text{g})$

$$\# \text{ mols } \text{CO}_2 = 3.77 \times 10^6 \frac{\text{mol}}{\text{d}} \cdot \frac{15 \text{ mol } \text{CO}_2}{1 \text{ mol } \text{C}_{15}\text{H}_{32}} = 5.65 \times 10^7 \text{ mols}$$

$$\# \text{ mols } \text{H}_2\text{O}(\text{g}) = 3.77 \times 10^6 \frac{\text{mol}}{\text{d}} \cdot \frac{16 \text{ mol } \text{H}_2\text{O}}{1 \text{ mol } \text{C}_{15}\text{H}_{32}} = 6.03 \times 10^7 \text{ mols}$$

$$\begin{aligned} \# \text{ mols } \text{N}_2(\text{g}) &= \# \text{ mols } \text{O}_2 \text{ consumed} \times \frac{78.01 \text{ mols } \text{N}_2}{20.95 \text{ mols } \text{O}_2} \\ &= 3.77 \times 10^6 \frac{\text{mol}}{\text{d}} \cdot \frac{23 \text{ mols } \text{O}_2}{1 \text{ mol } \text{C}_{15}\text{H}_{32}} \times \frac{78.01 \text{ mols } \text{N}_2}{20.95 \text{ mols } \text{O}_2} \\ &= 3.23 \times 10^8 \text{ mols } \text{N}_2(\text{g}) \end{aligned}$$

$$\text{total } \# \text{ mols gas in stack} = 4.40 \times 10^8 \text{ mols}$$

$$\therefore \# \text{ mols } \text{NO} = \left( \frac{75}{106} \right) \cdot 4.40 \times 10^8 \text{ mols} = 3.30 \times 10^4 \text{ mols } \text{NO}$$

$$\begin{aligned} \therefore \text{mass } \text{NO} &= 3.30 \times 10^4 \text{ mols} \times 30.0 \text{ g/mol} \\ &= 9.90 \times 10^5 \text{ g} \\ &= 9.9 \times 10^2 \text{ kg} \end{aligned}$$



5. / a) Pb - adsorbed on PM

∴ removed by i) electrostatic

ii) scrubber

solids

iv) cyclone

b)  $SO_2$  - gas (acidic)

∴ removed by ii) scrubber

v) SONOX process

$CaSO_4$

c)  $NO_x$  - gas (acidic)

ii) scrubber

v) SONOX

$Ca(NO_3)_2$

$NH_4NO_3$

or  $N_2$  (SONOX)

d) VOC's - organic compds

iii) oxidation

on Pd or Pt

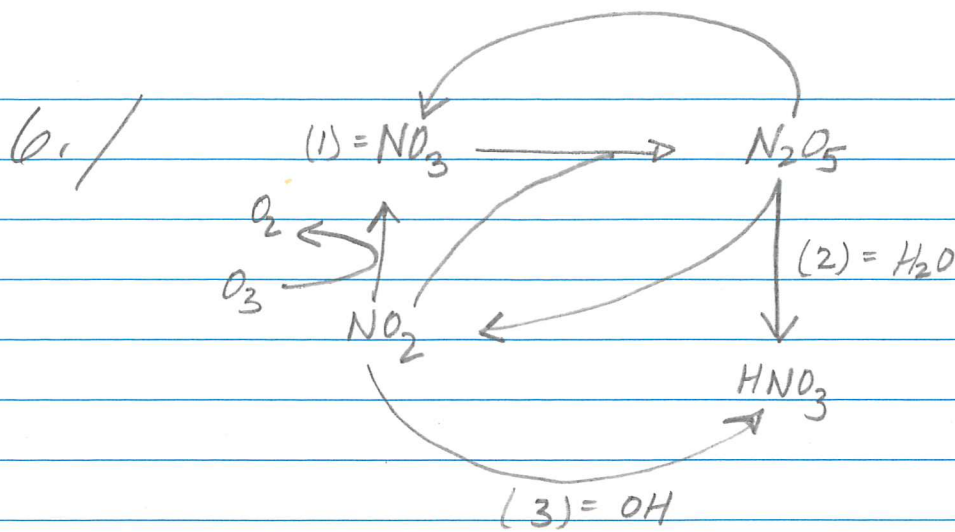
$CO_2(g)$

e) ultra-fine PM

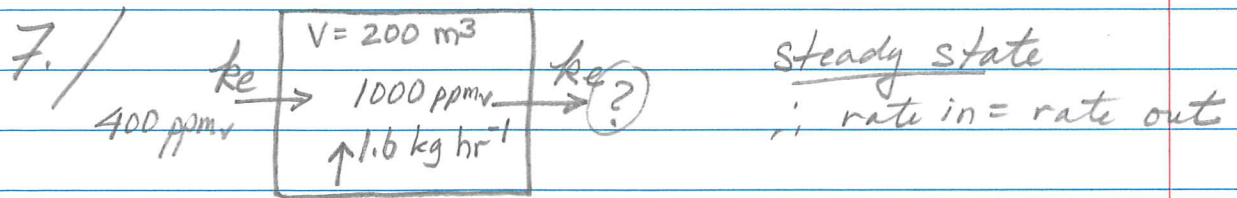
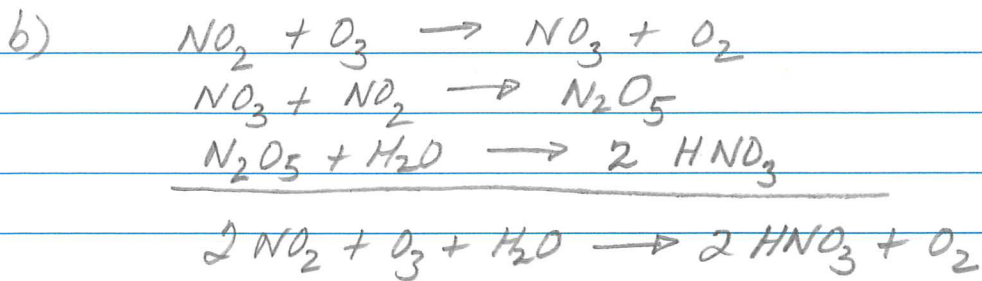
i) electrostatic

solids

(See section 5.7 & 6.3 textbook)



a) (1) =  $\text{NO}_3$  and (2) =  $\text{H}_2\text{O}$



$$ke(400 \text{ ppmv}) + \left( \frac{1.6 \text{ kg}}{\text{hr}} \cdot \frac{1}{200 \text{ m}^3} \right) = ke(1000 \text{ ppmv})$$

↑  
convert to  $\text{ppmv hr}^{-1}$

$$\frac{1.6 \text{ kg hr}^{-1}}{200 \text{ m}^3} = \frac{8.0 \times 10^{-3} \text{ kg}}{\text{m}^3 \text{ hr}} \times \frac{1 \text{ mol CO}_2}{0.044 \text{ kg}} \times \frac{1}{40.9 \text{ mols air}} \times 10^6$$

$$= 4.4 \times 10^3 \text{ ppmv hr}^{-1}$$

∴  $600 \text{ ppmv } ke = 4.4 \times 10^3 \frac{\text{ppmv}}{\text{hr}}$  and  $ke = \frac{4.4 \times 10^3 \text{ ppmv hr}^{-1}}{600 \text{ ppmv}} = 7.4 \text{ hr}^{-1}$