(1a) Pollutant 1: Ozone.

$$AQI = \frac{I_{HI} - I_{Lo}}{BP_{HI} - BP_{Lo}} \left(C_p - BP_{Lo} \right) + I_{Lo}$$

$$= \frac{300 - 200}{0.374 - 0.124} \left(0.2 - 0.124 \right) + 200$$

$$= 230.4 = \boxed{231}$$

Pollutant 2: CO

$$AQI = \frac{I_{HI} - I_{Lo}}{BP_{HI} - BP_{Lo}} \left(C_p - BP_{Lo} \right) + I_{Lo}$$

$$= \frac{150 - 100}{12.4 - 9.4} \left(10 - 9.4 \right) + 100$$

$$= 110$$

Pollutant 4: $SO_2 = 0.157 \text{ ppm}$.

$$AQI = \frac{I_{HI} - I_{Lo}}{BP_{HI} - BP_{Lo}} \left(C_p - BP_{Lo} \right) + I_{Lo}$$

$$= \frac{150 - 100}{0.224 - 0.144} \left(0.157 - 0.144 \right) + 100$$

$$= 108.1$$

Pollutant 5: $PM_{2.5}$

$$AQI = \frac{I_{HI} - I_{Lo}}{BP_{HI} - BP_{Lo}} \left(C_p - BP_{Lo} \right) + I_{Lo}$$

$$= \frac{200 - 150}{150.4 - 65.4} \left(150 - 65.4 \right) + 150$$

$$= 200$$

Pollutant 6: PM_{10}

$$AQI = \frac{I_{HI} - I_{Lo}}{BP_{HI} - BP_{Lo}} \left(C_p - BP_{Lo} \right) + I_{Lo}$$

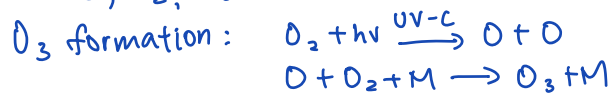$$= \frac{200 - 150}{354 - 254} \left(300 - 254 \right) + 150$$

$$= 173$$

∴ AQI = 230. Only unhealthy, not hazardous level

b) Yes, I agree with them.

The yellow and brownish color might be due to the formation of ground level ozone

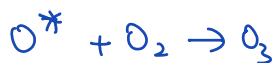due to a chemical reaction between NO_x and VOC_s in the presence of ==heat and sunlight==

$$VOC + NO_x + heat + Sunlight (uv) \rightarrow O_3$$

At Region B, the ozone present is naturally present due to equilibrium reactions

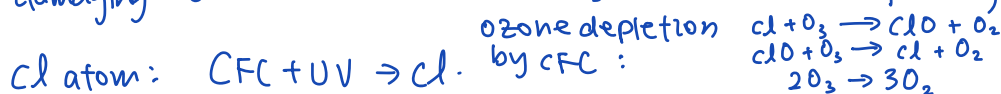between $O, O_2,$ and O_3 in the presence of UV.

O_3 formation: $O_2 + hv \xrightarrow{UV-C} O + O$

$$O + O_2 + M \rightarrow O_3 + M$$

O_3 destruction: $O_3 + hv \xrightarrow{UV-B} O_2 + O$

Production = Destruction.

At Region A, ozone is formed by a chemical reaction between NO_x

and VOC_s in the presence of heat and sunlight.

O_3 formation: $VOC + NO_x + heat + Sunlight (uv) \rightarrow O_3$

O_3 degradation: $NO_2 \rightarrow NO + O^*$

$$O^* + O_2 \rightarrow O_3$$
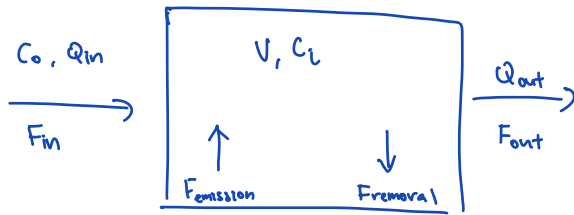
$$O_3 + NO \rightarrow NO_2$$

c) CO_2 is a greenhouse gas (GHGs) that traps heat in the atmosphere, causing

global warming.

other GHGs: CH_4, N_2O, CF_4

d) Yes, I agree. At stratosphere level, ozone helps shield us from highly

damaging UV-C and B. when CFCs reach the stratosphere, UV radiation liberates

Cl atom: $CFC + UV \rightarrow cl$. by CFC:

ozone depletion
$cl + O_3 \rightarrow ClO + O_2$
$ClO + O_3 \rightarrow cl + O_2$
$2O_3 \rightarrow 3O_2$

e) i) $V = 50 m^3$ $I = 1/h$ $K = 0.5/mth = 6.94 \times 10^{-4}/h$

C_o, Q_{in} $\boxed{V, C_L}$ Q_{out}

$F_{in} \longrightarrow$ $\uparrow$ $\downarrow$ $F_{out} \longrightarrow$

$F_{emission}$ $F_{removal}$

Assume :
$T = 25°C$, $P = 1 atm.$

$F_{EM} = \dfrac{3 \times 20 \times 25 mg}{16 h}$

$= 93.75 mg/h$

$C_o = 11 \cdot 43 \ mg/m^3$

Steady state $CO = \dfrac{F_{EM} + I V C_o}{(I+K)V}$

$= \dfrac{93.75 + 1(50)(11.43)}{(1 + 6.94 \times 10^{-4})(50)}$

$= 13.29 \ mg \ CO/m^3$

Duration for CO to reach $\sim 50\%$ of Steady state :

$e^{-(I+K)t} = e^{-0.5}$

$t = \dfrac{0.5}{1 + 6.94 \times 10^{-4}}$

$= 0.5 h$

$= 30 \ mins$

2a) $D = 3m$ $H = 50m$ $T = 20°C$, $P = 1 atm$

$\Delta h = \dfrac{V_s D}{u}\left[1.5 + 2.68 \times 10^{-3} PD\left(\dfrac{(T_s - T_a)}{T_s}\right)\right]$

$60 - 50 = \dfrac{V_s \times 3}{5}\left[1.5 + 2.68 \times 10^{-3} \times 1013 \times 3 \left(\dfrac{100-20}{100+273}\right)\right]$
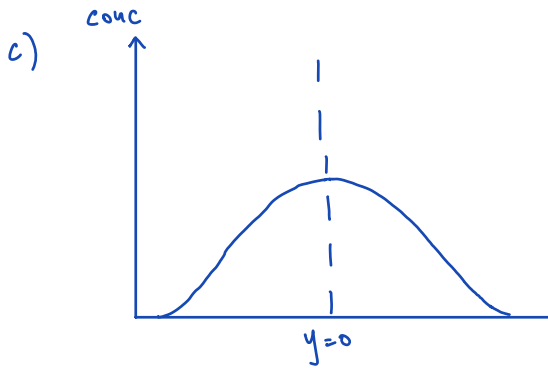
$\therefore V_s = 5.13 \ m/s$

b)   Stability class D , $u = 5m/s$ $z = 15m$ $\sigma_y = 33m$ $\sigma_z = 17m$ $Q = 50 kg/s$ $x = 400m$

CO conc   at apartment

$C(x,y,z) = \dfrac{Q}{2\pi \sigma_y \sigma_z u} exp\left(\dfrac{-x^2}{2\sigma^2_y}\right)\left(exp\left(-\dfrac{(z-H)^2}{2\sigma^2_z}\right)\right)$

$= \dfrac{50 \times 10^3}{2\pi \times 33 \times 17 \times 5}\left(exp\left(-\dfrac{(15-60)^2}{2 \times 17^2}\right)\right)$ $= 85374 \ \mu g/m^3$

c)

conc

y=0

Assuming high solar radiation, with the same wind speed and x distance, the stability class based on the Pasquill - Gifford Stability classes. Hence from the Pasquill-Gifford curves, σ_y and σ_z would be higher than previously. Using $C_{(x,y,z)} = \frac{Q}{2\pi \sigma_y \sigma_z u}$ for peak concentration, the peak concentration would be less than previously. Therefore, the mass of CO would be distributed across a larger area.

d) i) Temperature Gradient $\frac{\partial T}{\partial z} = \frac{30-34}{200-0} = \frac{-4°C}{200m} = \frac{-2°C}{100m}$

∴ stability class: A (extremely unstable)

ii) Formula for inversion layer

Assume same height above ground.

$H=52m \quad \sigma_y = 50m \quad \sigma_z = 30m \quad z = 15m$

$C_{(x,y,z)} = \frac{Q}{2\pi \sigma_y \sigma_z u} \exp\left(\frac{-y^2}{2\sigma_y^2}\right)^0 \left(\exp\left(-\frac{(z-H)^2}{2\sigma_z^2}\right) + \exp\frac{-(100-7)^2}{2\sigma_z^2} \right)$

$= 495933 \text{ } \mu g/m^3$

No inversion scenario

$C_{(x,y,z)} = \frac{Q}{2\pi \sigma_y \sigma_z u} \exp\left(\frac{-y^2}{2\sigma_y^2}\right) \left(\exp\left(-\frac{(z-H)^2}{2\sigma_z^2}\right) \right)$

$= 495933 \text{ } \mu g/m^3$

Comparing the numerical values, there is no significant impact on the CO concentration from the inversion layer.

3a) ☆ check if T required is lower than freezing point of benzene. $T = 41.9°F = 5.5°C$

Output benzene $= 8000 \text{ ppm} \times 2\%$

$\qquad = 160 \text{ ppm}.$ ∴ conc in liquid $= 4900 \text{ ppm}$

$$y_i = x_i \frac{P_i}{P} \qquad\qquad P = 1 \text{ atm} \qquad\qquad \log_{10} P = A - \frac{B}{(T+C)}$$

$$160 \times 10^{-6} = 0.99 \times \frac{P_i}{1} \qquad\qquad \log_{10}(0.12283) = 6.90565 - \frac{1211.033}{(T+220.790)}$$
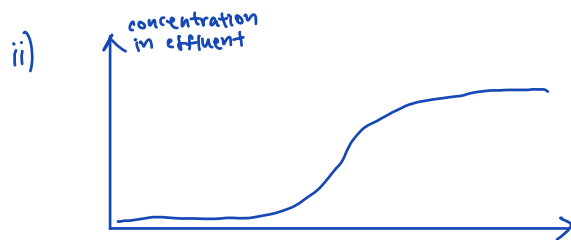
$$P_i = 0.12283 \text{ mmHg} \qquad\qquad T = -65.8°C$$
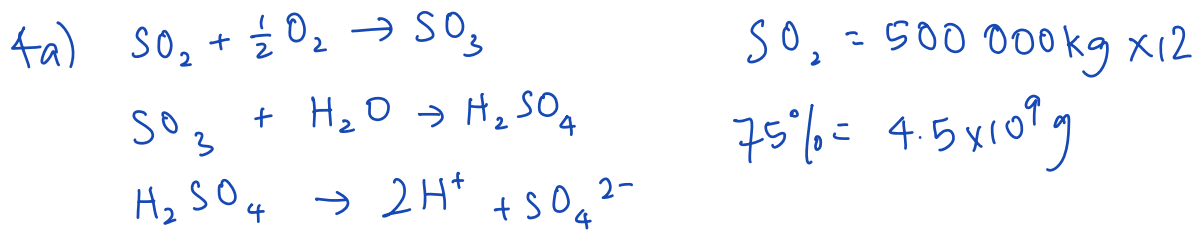
$$\downarrow$$

Temperature lower than freezing point of $5.5°C$

3bi) Adsorption works through physical or chemical adsorption. Physical adsorption involves the

weak bonding of gas molecules to the solid. Chemical adsorption works by chemical bonding by

reaction.

ii)

Concentration in effluent starts of close to zero. As time progresses, the adsorption medium

becomes increasingly saturated and the concentration in effluent exponentially increases and

approaches initial concentration. This means that the adsorption function has diminished to

insignificant level.

iii) absorption is the transfer of a gaseous component from the gas (absorbate) phase to a liquid

(absorbent) phase through a gas-liquid interface, dissolution into the liquid phase. Adsorption

involves the physical or chemical bonding of gas molecules to the solid.

4a) $SO_2 + \frac{1}{2}O_2 \rightarrow SO_3$ $SO_2 = 500\,000\,kg \times 12$

$SO_3 + H_2O \rightarrow H_2SO_4$ $75\% = 4.5 \times 10^9\,g$

$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$

$$pH = -\log_{10}[H^+]$$

initial $[H^+] = 10^{-5.6}$

$\qquad = 2.512 \times 10^{-6}\,M$

$\dfrac{mass}{\frac{mol}{mass}} = mol$

new $[H^+] = 10^{-3.5}$

$\qquad = 3.162 \times 10^{-4}\,M$

$\therefore$ Increase $= 3.162 \times 10^{-4} - 2.512 \times 10^{-6}$

$\qquad\qquad = 3.14 \times 10^{-4}\,M \qquad = 4.901 \times 10^{-6}\,g/l$

mol of $H^+ = \dfrac{4.5 \times 10^9 g \times 2}{64}$

$\qquad = 1.406 \times 10^8\,mol$

precipitation: $\dfrac{1.406 \times 10^8}{3.14 \times 10^{-4}\,M} = 4.479 \times 10^{11}\,l.$

Volume

$\qquad\qquad = 4.479 \times 10^8\,m^3$

annual precipitation $= 4.479 \times 10^8\,m^3 \div 600 \times 10^6\,m^3/yr$

$\qquad\qquad = 0.747\,m/yr$

b) $CaO + SO_2 \rightarrow CaSO_3$

SO2 is absorbed by a fine slurry mist of lime. The flue gas is hot and the liquid-to-gas ratio is

maintained such that the spray dries before it reaches the bottom of the chamber. The dry solids are

carried out with the gas, and collected in fabric filter or ESP.

c) i) $d_{15.9} = 6 \mu m$ $\sigma_g = 1.78$

$$\log d_{50} = \log d_{15.9} + \log \sigma_g$$
$$= 1.0286$$

$$d_{50} = 10.68 \mu m$$

$$\log_{84.1} = \log d_{15.9} + 2 \log \sigma_g$$
$$= 1.279$$

$$d_{84.1} = 19.01 \mu m$$

ii) cyclone removal device : has cut diameter of 5 μm

$\eta (\%)$

Particle diameter (μm)
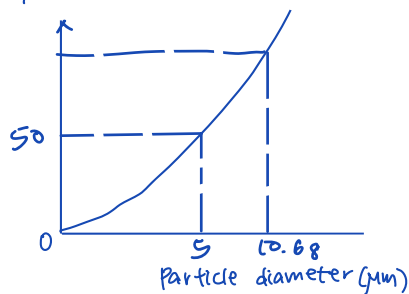
cut diameter of 5 μm for cyclone means that removal efficiency for
particles with diameter of 5 μm is at least 50%. Therefore, the removal
efficiency for particles with diameter 10.68 will definitely be over 50%.