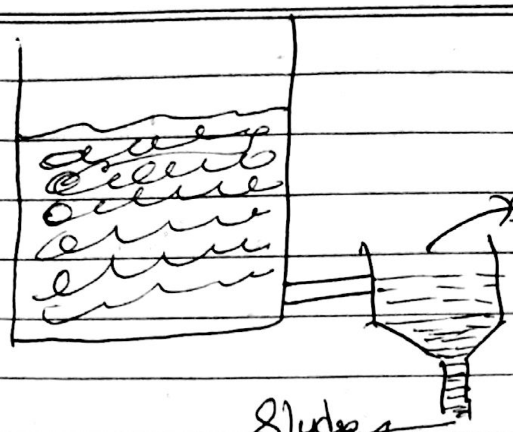
L-17
24/9/15

$1L = 10^{-3} m^3$



Q. A waterwaste treatment plant receives a flow of 35,000 m^3/d containing total amount of organic matter of 250 mg/L. Primary treatment removes 25% of organic matter. Calculate the no. of kickling filter (s). with diameter of 60 m. which would accomodate an organic load of 250 $g/m^2/d$. If the rate of O_2 required per kg At 0°C and 1 atm pressure density of air = 1201 kg/m^3 O_2 contain in air = 20.95 % ≃ 21 %
Also calculate amount of oxygen and air required to carry out the biodigredable organic matter.

Solⁿ:- Total amount of Biodegradable organic matter entering the filter = 250 mg/L × 0.75 × 35000 m^3/d.

$$= \frac{250\ mg}{10^{-3}\ m^3} \times 0.75 \times 35000\ m^3/d$$

$$= 250 \times 10^{3} \times 10^{-3} \frac{g}{m^3} \times \frac{75}{100} \times 35000\ m^3/d$$

$$= 25 \times 75 \times 35 \times 100$$

$$= 6562500\ g/d.$$

Total ~~organic matter~~ area required = $\dfrac{\text{total org. matter in w/w}}{\text{Org. load}}$

$$= \frac{6562500\ g/d}{250\ g/m^2/d}$$

$$= 26250\ m^2.$$

$\pi r^2 = 2831\ m^2$

No. of filters $= \dfrac{26250}{2831} \simeq 10$.

Amount of O_2 req. = rate of O_2 req. per kg of org. matter decomposed $\times$ total org. matter destroyed/day

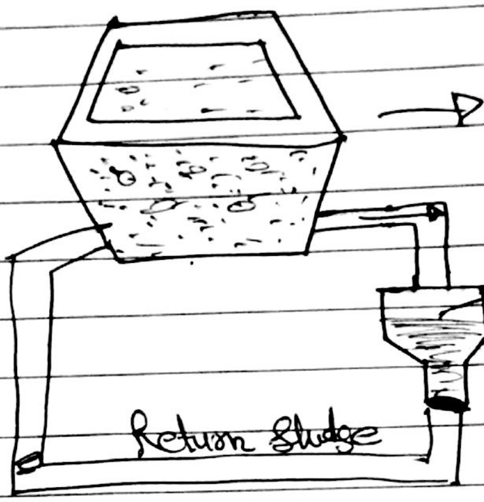
$$= 2\ \frac{kg\ of\ O_2}{kg} \times 6562500\ g/d$$
$$= 13125\ kg\ O_2/d.$$

Therefore air required $= \dfrac{13125\ kg/d}{21 \times 1.20\ kg/m^3}$

$$= 52039\ m^3/d$$

(I) Trickling filter Method
(II) "Activated" Sludge Method.

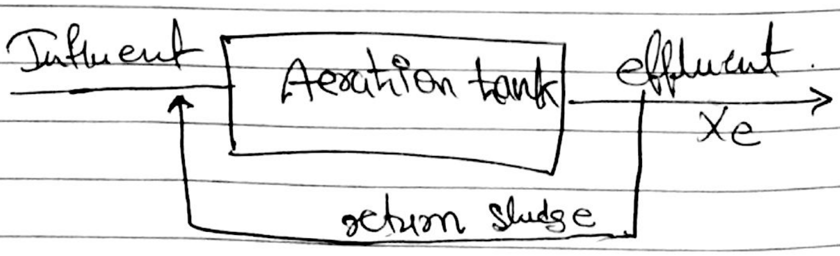
Biological Mass
X



Imp

Q. For activated sludge method, calculate the mean cell residence time (MCRT) and recirculation ratio (R) for given data:

(i) Average flow of waste water $= Q_0 = 10$ MLD
(ii) Effluent flow rate of W.W $= Q_e = 9.92$ MLD
(iii) Sludge wasting rate $= Q_w = 0.08$ MLD
(iv) Retention time $= \theta = 6$ hours
(v) Active biomass conc^n in reactor $= X = 3000$ mg/l
(vi) Biomass conc^n in effluent $= X_e = 20$ mg/l
(vii) Biomass conc^n in return sludge $X_R = 9000$ mg/l



volume of reactor $= 10 \text{ MLD} \times 6$ hours
$= 2.5$ ML

$$MCRT = \frac{\text{biomass in the reactor}}{\text{biomass removed from the reactor}}$$

$$= \frac{\text{Volume of reactor}(V) \times \text{Active biomass conc}^n (X)}{(\text{Sludge wasting rate}(Q_w) \times \text{Biomass conc}^n \text{ in return sludge}) + (\text{effluent flow of ww}) \times \text{biomass conc}^n \text{ in effluent}}$$

$$= \frac{10\,MLD \times 6\,hours \times 3000\,mg/L}{(0.08\,MLD \times 9000\,mg/L) + (9.92\,MLD \times 20\,mg/L)}$$

$$= \frac{2.5\,ML \times 3000\,mg/L}{(0.08\,MLD \times 9000\,mg/L) + (9.92\,MLD \times 20\,mg/L)}$$

$MCRT = 8.16$ days.

$$\boxed{\text{Recirculation ratio}(R) = \frac{\text{Ratio of Return flow }(Q_R)}{\text{influent flow }(Q_o)}}$$

$$\boxed{(Q_o + Q_r) \cdot X = Q_r \cdot X_r}$$

$(10 + Q_r) \times 3000 = Q_r \cdot 9000$

$Q_r = 5\,MLD$

$$R = \frac{5\,MLD}{10\,MLD} = \frac{1}{2}.$$

$\underline{\underline{R = 0.5}}$.

Scanned by CamScanner

L-18

Retention Time :-

$$R.T = \frac{\text{height of tank}}{\text{settling velocity}}.$$

Q. A wastewater treatment plant receives a flow of 35,000 m^3/d. Cal^n the mass of sludge wasted each day for an activated sludge ($Q_w X_w$ kg/d) system operated at solid retention time (SRT, θ_c) of 5 days?

Assume an aeration tank vol. of 1640 m^3 and a MLSS conc. of 2000 mg/L. What fraction of solids leaving the aeration tank?

Sol^n:- Setup for the SRT

$$\theta_c = \frac{X \cdot V}{X_w \cdot Q_w}$$

Return sludge conc^n

w (flow)

Mass of sludge wasted $= Q_w \times X_w$

$$\Rightarrow Q_w \cdot X_w = \frac{X \cdot V}{\theta_c} = \frac{1640 \times 2{,}000}{5}$$

$$= 656 \text{ kg/d}.$$

% of solids leaving the aeration tank

$$= \frac{656}{35{,}000 \times 2} \simeq 1\%.$$

$$\frac{F}{M} = \frac{\text{rate of flow} \times \text{conc of org. matter removed from w.w}}{\text{Vol}^n \text{ of aeration tank} \times \text{conc}^n \text{ of Biological mass}}$$

Sludge Treatment :-

1) Anaerobic digestion :-

~55°C → thermophilic digestion.
~36°C → mesophilic

Sequential mech^n of anaerobic digestion :-

Insoluble organics

↓ Enzymes

Soluble organics

↓ Acid producing bacteria

Bacterial cell + Volatile acids + other products

↓ Methane producing bacteria (methane fermentation)

$CH_4 + CO_2$ + Bacterial cell

(I) 50–75% $\Rightarrow CH_4$
25–45% $\Rightarrow CO_2$
$N_2, H_2, NH_3, H_2S \Rightarrow <1\%$

$\Rightarrow$ BIOGAS

$$CH_3CH_2COOH + 0.5\,H_2O \xrightarrow{\text{Microorganism}} 1.75\,CH_4 + 1.25\,CO_2$$

Sludge Cake :-

Q. Determine quantity & vol of raw sludge produced in the treatment of 5000 m^3/d of domestic w/w with the following condn.

(i) Solid content of raw sludge $\Rightarrow$ 4%
(ii) S.P gravity of raw sludge $\Rightarrow$ 1.02
(iii) Rate of raw sludge generated = 0.1 kg/m^3.
(iv) Digestion time = 15 days
(v) Quantity of solids in the digested sludge = 290 kg
(vi) SP gravity of digested sludge = 1.004.
(vii) Solid concn in digested sludge = 10%

Also calculate vol of anaerobic digestor?

Solns:- Quantity of raw sludge
= rate of sludge generated × total amt of ww/d

= 500 kg/d.

$$1000\,cm^3 = 1\,l$$

$$1\,m^3 = 1000\,l$$

Vol^m of raw sludge $= 1225\,m^3$.
Vol^m of digested sludge $= 280\,m^3$.

% reduction in sludge vol^m

$$= \frac{\text{vol}^m \text{ of raw-sludge} - \text{vol}^m \text{ of digested sludge}}{\text{vol}^m \text{ of raw sludge}}$$

$$= 77.14\,\%$$

vol^m of anaerobic digestor

$$\Rightarrow \left[V_{sl(r)} - \frac{2}{3}\left(V_{sl(r)} - V_{sl/d}\right)\right] \times \text{digestor time}$$

$$= 89.25\,m^3.$$

1 lecture is left

$1 m^3 = 1000 l$
$1000 cm^3 = 1 l$.

L-18

L-19

Q. 10 MLD of wastewater with influent COD of 8000 kg/d is treated in an anaerobic digester. 70% of COD removal was reported. Cal. the vol. of methane per day at STP.

Solⁿ:-

amount of COD = 70% of 8000 kg/d

= 5600 kg/d.

The conversion factor b/w COD & methane in 0.25 kg of CH_4/kg of COD.

1 kg COD → 0.25 kg CH_4

→ 5600 × 0.25 kg of CH_4

methane production = 1400 kg of CH_4

1 mole CH_4 = 22.4 lt.

at STP 16 gm CH_4 = 22.4 lt.

1400 kg = 1960×10^3 lt.

Tertiary Treatment :-

(A) Removal of Ca & Mg :-

$5Ca^{+2} + 3PO_4^{3-} + OH^{\ominus} \longrightarrow \boxed{Ca_5OH(PO_4)_3} \downarrow$

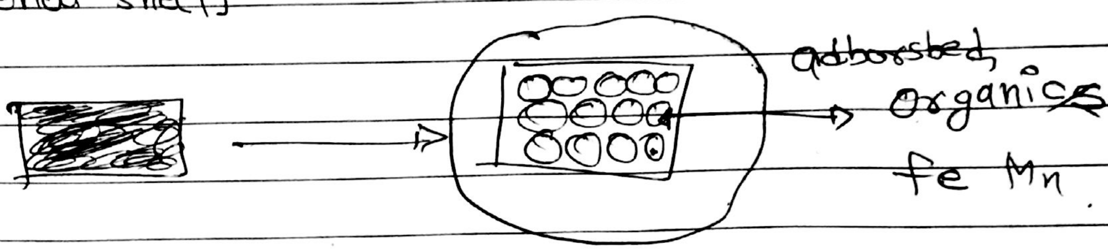
(B) Removal of Iron & Manganese :-

II → III   II → VII (MnO_4^-)

Adsorption on activated Carbon / charcoal :-

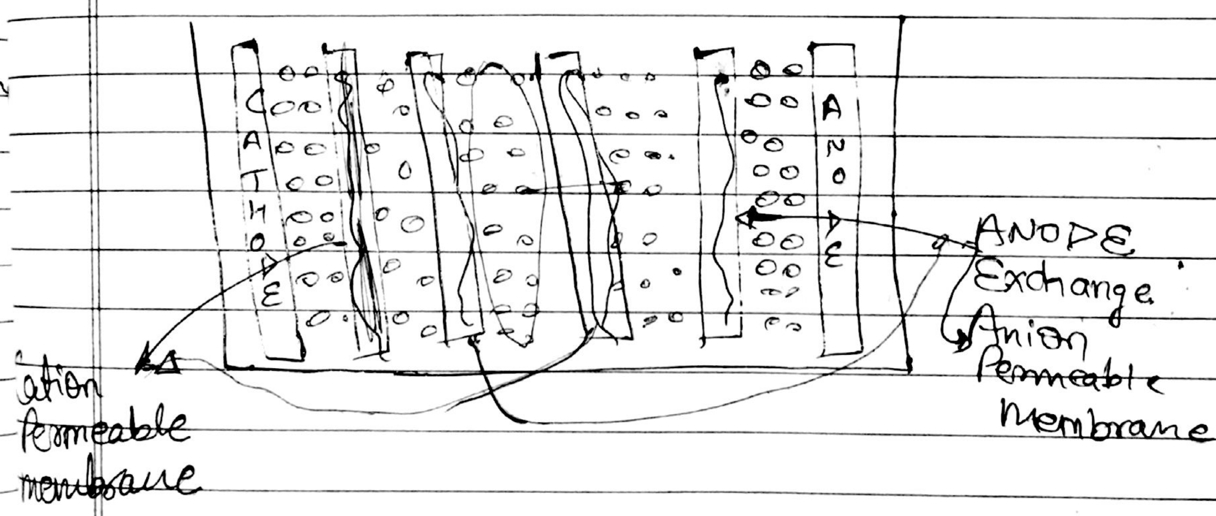
Coal
Wood
Coconut sheel

$\xrightarrow[\text{Carbonization}]{600-800^\circ C}$ int. pdt $\xrightarrow[\text{gasification}]{\text{steam}, O_2}$ activated Carbon.

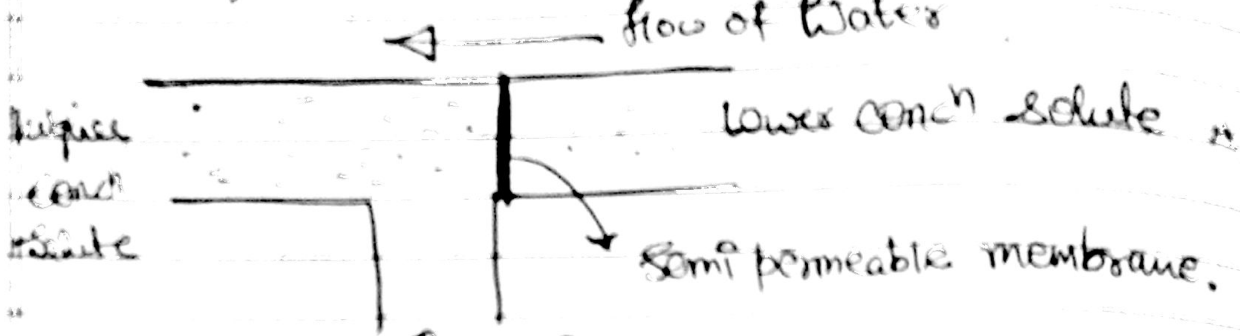


(C) Removal of Dissolved Inorganics :-

Electrodialysis & Reverse Osmosis. (RO).

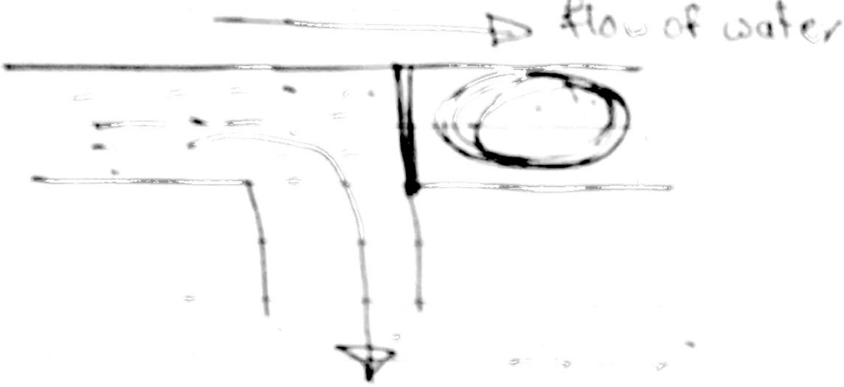


Reverse Osmosis Method :-



Osmosis

Reverse Osmosis



(2) Removal of heavy Metals :-

⇒ (a) Precipitated as S^{2-}

(b) Electrodeposition.

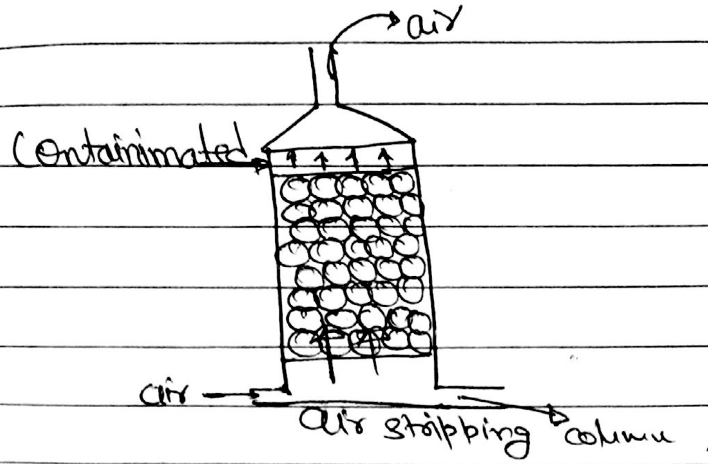
(c) Reverse Osmosis

(D) Electrodialysis.

1-20
5/10/15

Removal of Nitrogen :-

(i) Ammonia Stripping method :-



$$NH_4^{\oplus} + OH^{\ominus} \longrightarrow H_2O + NH_3 \uparrow$$

$$\boxed{P_H \rightarrow 10.8 - 11.5}$$

(ii) Nitrification followed by disnitrification :-

Remember

$$2NH_4^{\oplus} + 3O_2 \xrightarrow{\text{Microorganism}} NO_2^{\ominus} + 4H^+ + 2H_2O.$$

$$2NO_2^{\ominus} + O_2 \xrightarrow{\text{Nitrobacteria}} 2NO_3^{\ominus}$$

(a) $6NO_2^{\ominus} + 5CH_3OH + 6H^{\oplus} \xrightarrow[\text{bacteria}]{\text{dentrifying}} 3N_2(g) + 5CO_2 + 13H_2O$

(iii) $2NH_3 + 2HOCl \longrightarrow N_2(g) + 3H_2O + 3HCl.$

classmate
Date
Page

★ Removal of Dissolved Biorefractory organics:-

Water Disinfection :-

(a) by chlorine :- to kill pathogen.

$H_2O + Cl_2 \rightarrow H^{\oplus} + Cl^{\ominus} + HOCl$.

$HOCl \rightleftharpoons H^+ + OCl^{\ominus}$.

$(HOCl \ \& \ OCl^{\ominus}) \Rightarrow$ free available chlorine.

(b) $NH_4^{\oplus} + HOCl \rightarrow \boxed{NH_2Cl} + H_2O + H^{\oplus}$.

$NH_2Cl + HOCl \rightarrow \boxed{NHCl_2} + H_2O$.

$NHCl_2 + HOCl \rightarrow \boxed{NCl_3} + H_2O$.

$NCl_3 \rightarrow N_2(g)$

Combined available Chlorine.

Final rxn: $\boxed{2NH_3 + 3HOCl \rightarrow N_2(g) + 3H_2O + 3HCl}$ Overall Rxn.

$Cl_2 + H_2O \rightarrow HOCl$

$HOCl \rightarrow H^{\oplus} + OCl^{\ominus}$

Break Point:- (7.6 : 1)

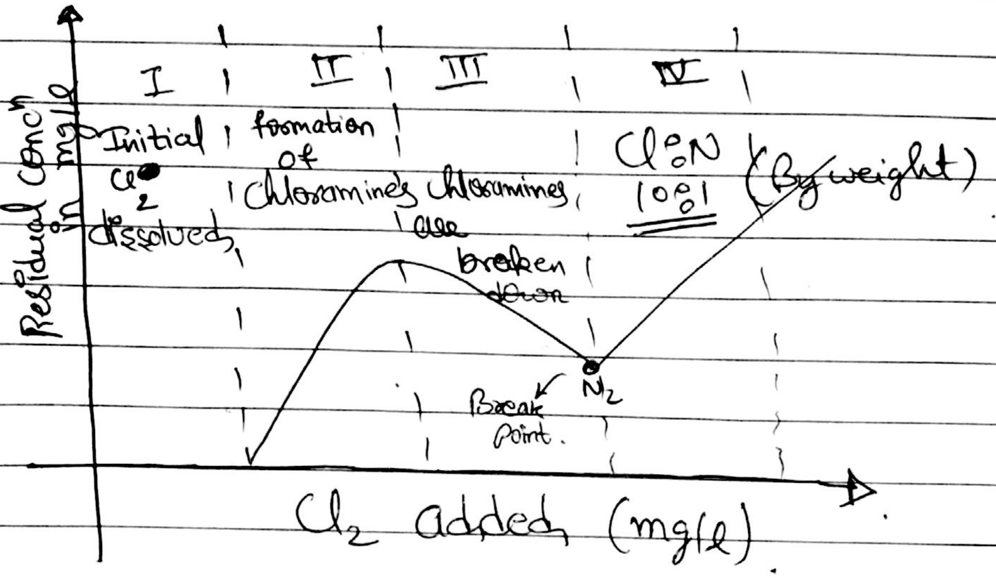
The ratio of Cl : N (where all the nitrogeneous Comp. have oxidised to $N_2(g)$)

$Cl : N \xrightarrow{Cl_2} HOCl + OCl^-$

$Cl : N$

$(10 : 1)$

to kill bacteria ← (Break point chlorination)



$Fe^{+2} + H_2S + Cl_2 \longrightarrow Fe^{+3}, S\downarrow$

Q. Determine the chlorine setting need to treat a flow 4 MGD with a Cl_2 dose of 5 mg/L.

Sol^n:-

Chlorine feed rate = Chlorine dose × flow

$= 5\ mg/L \times 4\ MGD$.

pound

$\boxed{1\ mg/L = 8.34 \times 10^{-6}\ lb/gal}$

$= 5 \times 4\ MGD \times 8.34 \times 10^{-6}\ lb/day$

$= 167\ lb/day$.

BPC → Breakpoint chlorination amount.

Date
Page

Q. A water sample found to have Cl_2 demand Of 1.76 mg/l. If the desired Cl_2 residual in 0.9 mg/l what is desired Cl_2 d

Solⁿ:- Chlorine dose = Chlorine desired + Chlorine residual

= 1.76 mg/l + 0.9 mg/l

= 2.6 mg/l.

Q. Calculate the chemical charge achieve BPC in 60,000 Gal Tank with FC of 1.5 mg/L and TC of 2.3 mg/L. What would be the amount of Ca(OCl) Cl. Needed if the Cl_2 sour is 67% Of Calcium hypochlorite.

Solⁿ:- Combined chlorine (CC) = 0.8 mg/L.

BPC amount = 8 mg/L. (as Cl : N 10 : 1)

Desired charge amount (DC) = (8 − 1.5) mg/l

= 6.5 mg/l.

Cl_2 dose = 6.5 mg/l × 60,000 Gal

= 3.25 lb

as Cl_2 is 67%

$= \frac{3.25}{0.67}$

= 4.85 lb

(i) SO_2 / Na_2SO_3

(ii) Chlorine dioxide. $ClO_2 \xrightarrow{e^{\ominus}} ClO_2^{\ominus}$ → to kill bacteria.

(iii) Ozone (O_3) :-

↳ No sideeffect.

$O_3 \longrightarrow O_2 + [O]$ → oxidising agent.

↓

break down the bond of microorganism.

* Removal of taste & Odour :-

→ absorbtion of charcoal

→ Oxidisizing agent.

9/10/15

2-2

Atmosphere

Atmosphere :

Physical characteristics of atmosphere :-

(i) $N_2 = 78\%$ (by vol.)
$O_2 = 20\%$ or 21%
$Ar = 0.934\%$
$CO_2 = 0.033\%$
water vapour = 0 - 3 or 4%.

(ii) Density ↓ with increasing altitudes.
⇒ >99% of total mass of atm is found within 30 km of earth surface.

> The total mass of global atmosphere is approx. 5×10^{15} metric tones.

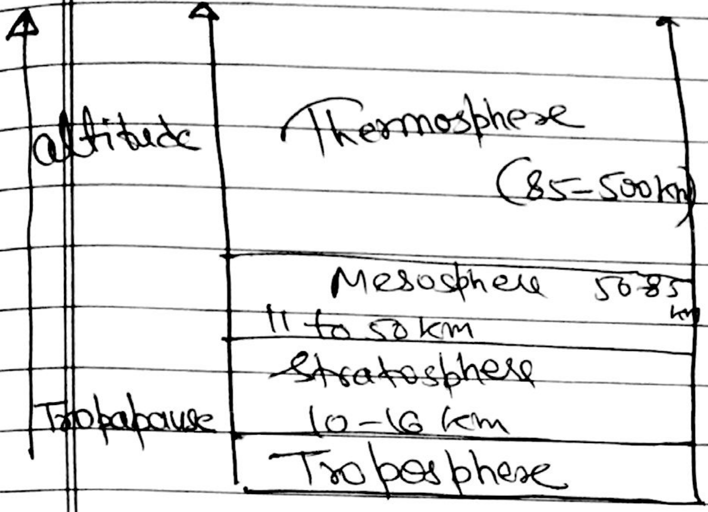
(iii) Temp. varies from $-92°C$ to $200°C$.

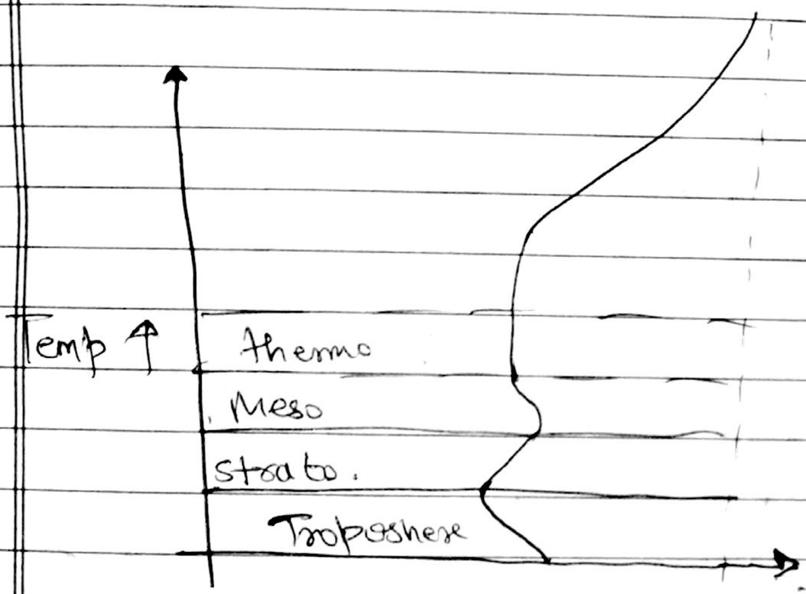
(iv) Atmospheric pressure is varies from 1 atm at sea level to 30×10^{-7} atm at 100 km above sea level

★ Major regions of atmosphere :-

Troposhere	to $-56°C$	O_2, CO_2, N_2, H_2O, Ar
Stratosphere	$-50°C$ to $-2°C$	O_3
Mesosphere	$-2°C$ to	O_2^+, NO^+
Thermosphere	$-92°C$ to $1200°C$	O_2^+, $O^{\oplus}$, $NO^{\oplus}$.

⇒ Ozone is considered pollutant in troposhere but helpful in stratosphere.





Evolution of atmosphere :-

Major gaseous molecule — Minor gaseous element from

H_2O, SO_2, CO_2 — N_2, H_2S. Valcanic rxn.

$$4Fe^{+2} + O_2 + 4H_2O \longrightarrow 2Fe_2O_3 + H^{\oplus}$$

ferric oxide

Fe_3O_4
Magnetite

⇒ Nitrogen is very much unreactive in natur

$$CO_2 \xrightarrow{\text{U.V light}} CO + [O]$$

$$H_2O \xrightarrow{\text{UV light}} OH + [O]$$

$$[O] + [OH] \xrightarrow[\text{light}]{\text{UV}} \underline{O_2} + \underline{H}$$

$$O_2 + \xrightarrow[\text{light}]{\text{UV}} [O] + O$$

$$O_2 + O \xrightarrow[\text{light}]{\text{UV}} O_3.$$

⇒ Plant started to grow & carry out photosy

Data:- In a day
human being consump
of 3 cylinder of Oxygen.

O_3 + hydrocarbon → Product gas
(invisible) (invisible) (invisible)

hydrocarbon → naturally occuring (Ex, CH_4, tarpin)
hydrocarbon → man made → VOC (ex: solvent)

Product gas → Condensed → visible cloud → brown cloud

droplets & particles → visible cloud

Air Pollution

1) CO_2 2) CO 3) SO_2 4) O_3
5) Participants matter (PM).
6) Lead 7) Nitrogen oxides (NO_x)

CO ⇒ results from the incomplete combustion of fuel.
CO_2 ⇒ results from the complete combustion of fuel.

$$\text{fuel} + O_2 \xrightarrow[\text{combustion}]{\text{incomplete}} CO + H_2O + \text{energy} \Rightarrow \text{indoor air}$$

$$\text{fuel} + O_3 \xrightarrow[\text{Combustion}]{\text{Complete}} CO_2 + H_2O + \text{energy} \quad Fe^{II}$$

Air Quality Index (AQI)

⇒ ratio of measured to accepted conc^n x100

$$AQI_{CO} = \frac{3\text{ ppm}}{9\text{ ppm}} \times 100$$
$$= 33\%$$

Smog :-

Photochemical Smog	Chemical smog
→ Summer	→ Winter
→ Warm day sunny climate	→ Cool humid climate
→ O_3	→ SO_2
→ Los-Angeles type Smog (1940's)	→ 1952 ⇒ great London Smog.
→ Oxidising smog	→ also known as reducing smog

Photochemical Smog :-

I: $N_{2(g)} + O_{2(g)} + \text{high temp.} \longrightarrow 2NO(g)$

II: $2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$

Nitrogen oxide

III $NO_2 \xrightarrow{\text{Sunlight}} NO(g) + O(g)$

IV: $O(g) + O_2(g) \longrightarrow O_3(g)$.

V: O_3 + hydrocarbons ⟶ product gas

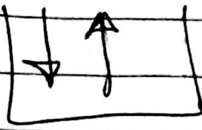
hydrocarbons (invisible) ⟶ naturally Occurring (CH_4, terpin) ; Man made (VOC)

product gas (invisible) ⟶ Condensed ⟶ Visible cloud ⟶ brown cloud

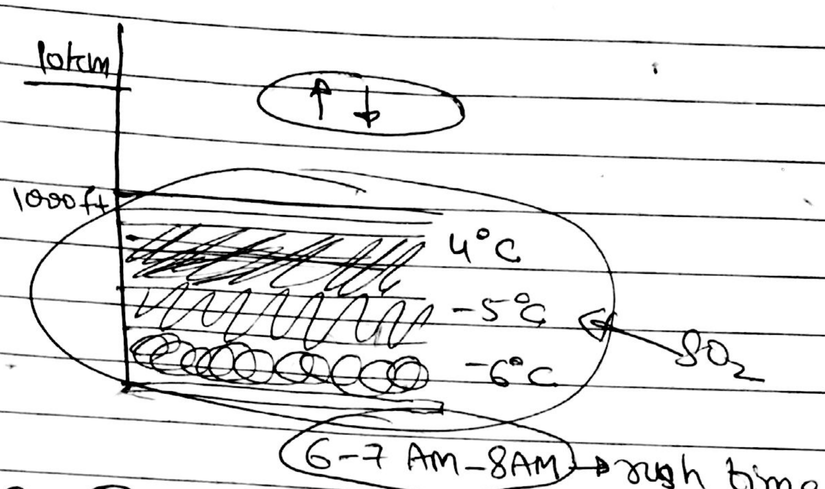
droplets / parti ⟶ Visible cloud

Classical Smog

Inversion layer

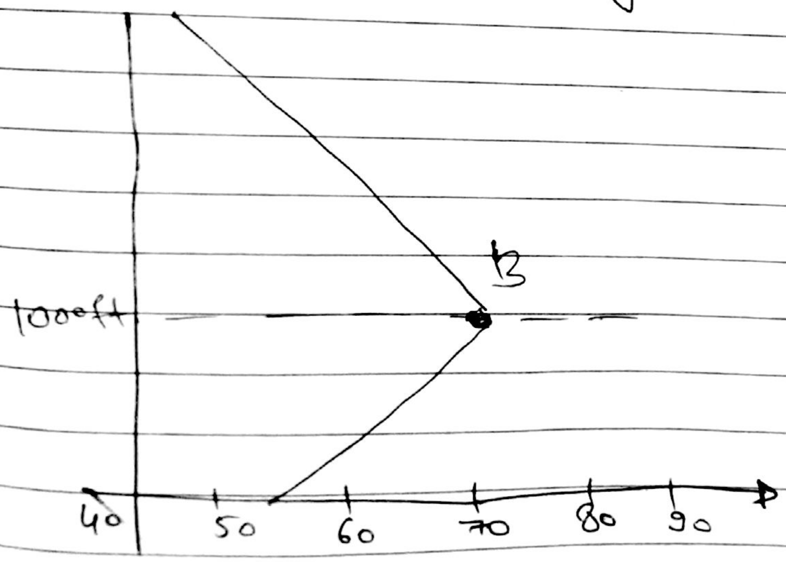


1) During winter, early in the morning.
2) Winds are calm.
3) Clear sky.



Inversion layer :- This creates a stable layer. up & Down air motion is there.

⇒ No mixing.



In presence of SO_2 bacterial infection is occured.

Q. Given that flow of the O_2 into & out of the earth's atmosphere is 3×10^4 kg/year. What is residance time of O_2 in the earth's atmosphere.

(a) given vol. of atm at $15^\circ C$ & at 1 atm pressure is 4.3×10^{21} L.

(b) Concn of oxygen = 21% of dry atm.

Sol^n: F_{in} = flow rate in units of amount / unit time

$$F_{in} \longrightarrow \boxed{\text{Compartment (air atm) (lake)}} \longrightarrow F_{out}$$

M = total amt of material in the compartment

$$\tau = \frac{M}{F}$$

Residence time

$$M = 4.3 \times 10^{21}\,(L) \times (0.21)$$

22.4 l at STP = 32 g

$$\Rightarrow 4.3 \times 10^{21} = \frac{32}{22.4} \times 4.3 \times 10^{21} \times L \times \frac{273}{288}\ g$$

$$= 1.2 \times 10^{18}\ kg$$

$$\tau = 4000\ yrs$$