Q1 A stack in an urban area is emitting 80 g/sec of NO_x. It has an effective stack height of 200 m the wind speed is 4 m/sec. at 10 m. It is a clear summer day with the sun nearly overhead. Estimate the ground level concentration at

a) 2 km down wind on the centreline and

b) 2 km downwind, 100 m off the centreline.

Soln:- Given

$X = 2000\,m$ (downwind)

Emission Rate = 80 gm/sec.

Effective stack Height (H) $= h + \Delta h =$ 200 m.

Wind speed at 10 m (u_1) = 4 m/sec.

The wind speed at 200 m can be calculated using formula

$$u_2 = u_1 \left(\frac{z_2}{z_1}\right)^P$$

It is mention in question that it is a clear summer day with the sun nearly over head means it's belong to Neutral class (D).

From the dispersion coefficient graph for stability class D for $X = 2\,km$ the value of

$\sigma_z = 50\,m$.

$\sigma_y = 130\,m$

And the table,

Stability class	A	B	C	D	E	F
Rural	0.07	0.08	0.10	0.15	0.35	0.55
Urban	0.15	0.17	0.20	0.25	0.30	0.35

the value of P from here is 0.25

So the wind speed at 200 m $(u_2) = u_1 \times \left(\frac{z_2}{z_1}\right)^P$

$$= 4 \times \left(\frac{200}{10}\right)^{0.25}$$

$$= 4 \times 2.11$$

$$= 8.45\,m.$$

The formula for calculating ground level concentration at centreline of Plume $(y=0)$ at Height H.

$$C_{x,0} = \frac{Q}{\pi u \sigma_y \sigma_z} e^{-\frac{1}{2}(H^2/\sigma_z^2)}$$

$X = 2000\,m$

$$C_{2000,0} = \frac{80}{3.14 \times 8.45 \times 130 \times 50} e^{-\frac{1}{2}\left(\frac{200}{50}\right)^2}$$

$$= 0.000000155\ gm/m^3$$

$$= 0.155\ \mu gm/m^3 \text{ (Ans)}$$

b) 2km downwind and 100 m off the centreline

means Here $X = 2000\,m$

$Y = 100\,m$

$$C_{x,y} = \frac{Q}{\pi u \sigma_y \sigma_z} e^{-\frac{1}{2}(Y^2/\sigma_y^2)} \cdot e^{-\frac{1}{2}(H^2/\sigma_z^2)}$$

$$C_{2000,100} = \frac{80}{3.14 \times 8.45 \times 130 \times 50} e^{-\frac{1}{2}(100/130)^2} \cdot e^{-\frac{1}{2}(200/50)^2}$$

$$=$$

$$= 1.15 \times 10^{-7}\ gm/m^3$$

$$= 0.11564\ \mu gm/m^3.$$

Q2 An industrial boiler is burning at 12 tons of 2.5% sulphur coal/hr with an emission rate 151 gm/sec. the following exits: H = 220 m u = 2 m/s y = 0. It is one hour before sunrise and the sky is clear. Find the downwind ground level SO_2 concentration at x = 2 km y = 0 z = 0.

Soln
Emission rate (Q) = 151 gm/sec.
Stack Height (H) = 220 m
Wind speed (u) = 2 m/s.
down wind distance for stack x = 2 km = 2000 m
cross wind distance (y) = 0
z = 0

It is given in the question that It is one hour before sunrise and the sky is clean so it belong to stability class F. (Stable)

from the dispersion coefficient graph for stability class F the σ_y & σ_z is:

$\sigma_y = 70$
$\sigma_z = 20$

The ground level concentration can be calculated from

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

But Here y = 0 and z = 0 so.

$$C_{x,0,0} = \frac{Q}{\pi \sigma_y \sigma_z u} e^{-\frac{1}{2}(H^2/\sigma_z^2)}$$

$$= \frac{151}{3.14 \times 70 \times 20 \times 2} e^{-\frac{1}{2}(220/20)^2}$$

$$= 9.13 \times 10^{-29} \text{ gm/m}^3$$

$$= 9.13 \times 10^{-23} \ \mu\text{gm/m}^3 \quad \text{Ans}$$

Q3 A 500 MW thermal power plant burns 18 000 tons of coal per day containing 0.58% sulphur. The plant emits the flue gasses in to the atmosphere through a stack of inside diameter 1.5 m and height of 60 m. the velocity and the temperature of the plume at the exit are 5 m/sec and 155°c respectively. The ambient air temperature is 28°c and the wind speed at the stack altitude is 7 m/s. the barometric pressure is 825 milibar at the top of the stack. Assume a moderately stable plume.

a) Calculate the effective height of stack.

b) What is the downwind SO_2 concentration in the plume centreline at a distance of 2 km in the day time?

c) Calculate the maximum concentration of SO_2 along the centreline of the plume and at what downwind distance it will occur.

d) Show a concentration profile of SO_2 up to 10 km downwind distance and 800 m along the cross wind distance.

Soln Stack diameter = 1.5 m

stack height (h) = 60 m

Velocity of stack (V_s) = 5 m/sec.

Stack temperature (T_s) = 155°c + 273 = 428 K.

Ambient air Temperature T_a = 28°c + 273 = 301 K

Pressure = 825 milibar.

wind speed at stack altitude (u) = 7 m/sec.

a) Now we have to calculate effective stack Height

$H = h + \Delta h$

Δh can be calculated using formula:-

$$\Delta h = \frac{V_s D}{u}\left[1.5 + 2.68\times10^{-3}\cdot P\cdot D\left(\frac{T_s - T_a}{T_s}\right)\right]$$

$$= \frac{5\times1.5}{7}\left[1.5 + 2.68\times10^{-3}\times 825\times1.5\left(\frac{428-301}{\cancel{301}\ 428}\right)\right]$$

$$= \frac{5 \times 1.5}{7}\left[1.5 + 2.68 \times 10^{-3} \times 825 \times 1.5 \times \cancel{0.437}\ 0.296\right]$$

$$= 1.07 \times \left[1.5 + \cancel{1.396}\ 0.984\right]$$

$$= 1.07 \times 2.\cancel{896}\ 484$$

$$= \cancel{3.098}\ 2.657\,m$$

Effective stack Height $H = h + \Delta h v$

$$= 60 + \cancel{3.098\,m}\ 2.657\,m$$

$$= \cancel{63.098\,m}.\ \cancel{(Ans)}\ 62.657\,m\ (Am)$$

(b) The downwind SO_2 concentration in the plume centerline at a distance of 2km in the day time.

For this we have to calculate emision rate of SO_2 (Q)

this power plant burns 18000tone / day of coal containing 0.58% sulphur content so

$$Q = 18000\ \text{tons/day} = \frac{18000 \times 10^3}{24 \times 60 \times 60}\ \text{kg/sec.} = 208\ \text{kg/sec.}$$

Sulphur content = 0.58%.

$$= 208.33 \times 0.0058$$

$$= 1.208\ \text{kg/sec.}$$

Q. 2. $S + O_2 \longrightarrow SO_2$

Sulphur per second = 208.33×0.0058 = 1.208 kg/sec.

1 mol of sulphur produces 2kg of SO_2

$$SO_2 = 2 \times 1.208$$

$$SO_2 = 2.416\ \text{kg/sec.}$$

$$Q = 2416\ \text{gm/sec.}$$

From The dispersion coefficient graph at 2km at stable (F) class

$\sigma_y = 70$ $\quad \sigma_z = 20$

For the concentration of SO_2 at centreline $y=0$

$$C_{x,0} = \frac{Q}{\pi u \sigma_y \sigma_z} \cdot e^{-1/2\, H^2/\sigma_z^2}$$

$$= \frac{2416}{\underbrace{3.14 \times 7 \times 70 \times 20}_{0.0785}} \; e^{\underbrace{-1/2 \left(\frac{62.657}{20}\right)^2}_{0.00740}}$$

$= 0.000580 \ gm/m^3$

$= 580 \ \mu g/m^3$ (Am)

ⓒ The maximum concentration of SO_2 along the centreline of the plume & at what down wind distance it will occur.

For maximum concentration of SO_2 $\sigma_z = 0.707H$

$\sigma_z = 0.707 \times 62.657$

$= 44.298 \ m$

From the dispersion coefficient graph for $\sigma_z = 44.298$ the down wind distance $X = 10.3$ km

$= 10300$ meter.

From this graph $\sigma_y = 300$ m

The maximum concentration of SO_2

$$C_{max} = \frac{Q}{\pi u \sigma_y \sigma_z} \, e^{-1/2\, H^2/\sigma_z^2}$$

$$= \frac{2416}{\underbrace{3.14 \times 7 \times 300 \times 44.298}_{0.00827}} \; e^{\underbrace{-1/2 \left(62.657/44.298\right)^2}_{0.3678}}$$

$= 0.003042 \ gm/m^3$

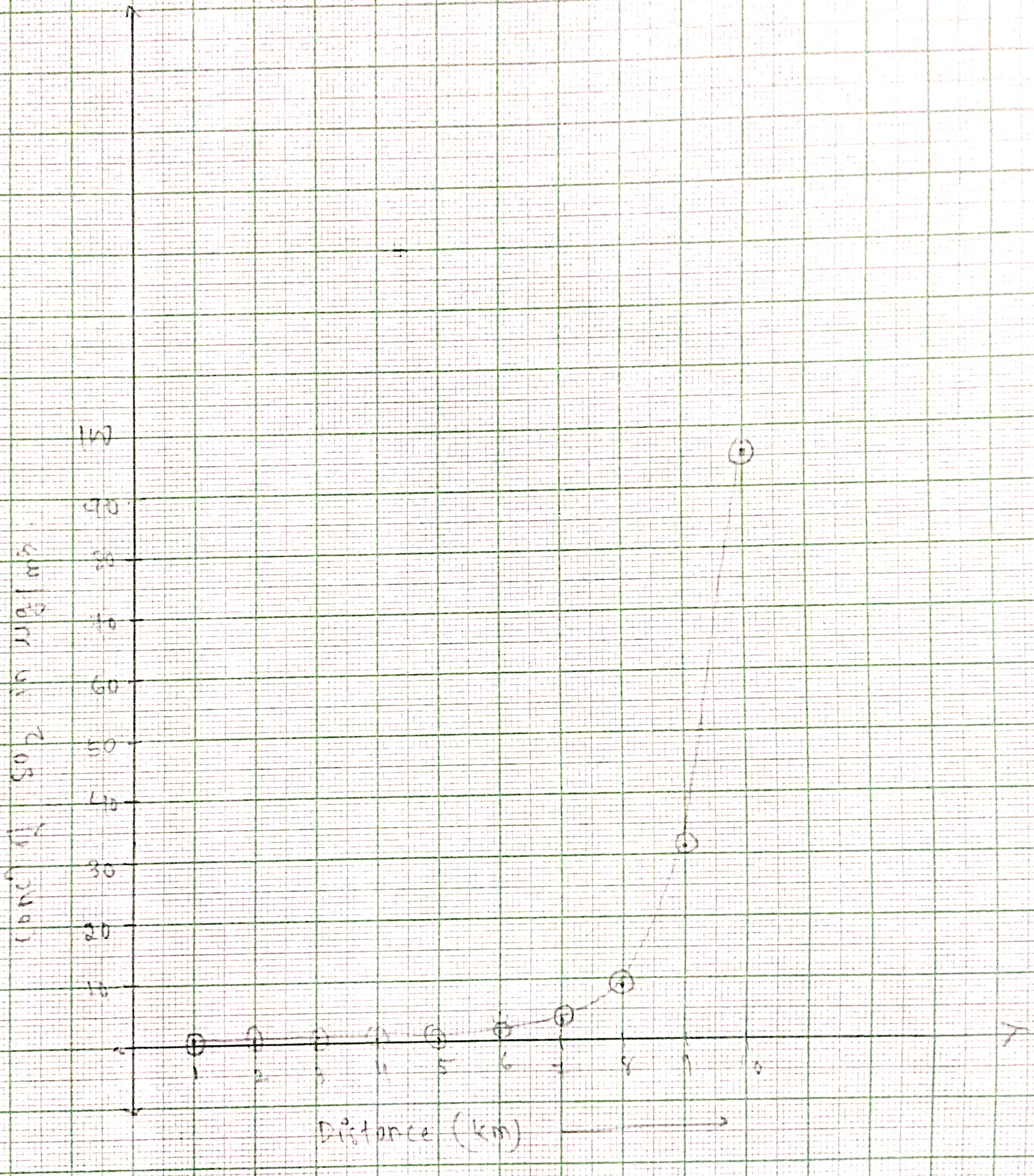
$= 3042 \ \mu g/m^3$ Am.

d) Concentration profile of SO_2 up to 10 km down wind and 800m along the cross wind distance.

$$C_{x,y} = \frac{q}{\pi u \sigma_y \sigma_z} e^{-\frac{1}{2}(H/\sigma_z)^2} \cdot e^{-\frac{1}{2}(y/\sigma_y)^2}$$

$y = 800m. = 0.8km$

S. No	Distance (Km)	σ_y (m)	σ_z (m)	C_{SO_2} $\mu g/m^3$
1	1	35	16	0
2	2	71	22	0
3	3	93	26	0
4	4	130	30	0
5	5	150	35	0
6	6	190	38	0.5
7	7	200	42	1.44
8	8	230	43	9.07
9	9	260	46	31.95
10	10	300	50	95.43.



Conc. of SO_2 in µg/m³
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
Distance (km)

Q4/ A stack gas from a cement clinker emit dust at the rate of 115.0 gm/sec. at a temperature of 175°c, velocity 8 m/sec and barometric pressure of 977 milibars. A slightly unstable Plume is found at the exit of the chimney. The ambient air temperature is 30°c and wind velocity is 4 m/sec. A chimney of 96cm diameter may be used for dispersion. Under slightly unstable condition calculate:-

a) Effective stack Height ?

b) The concentration of dust at a distance of 6km downwind along the centralline of the plume

c) Maximum ground level concentration of dust and at which it will occur ?

Soln:- Given:-

Emission rate of stack gas $(Q) = 115$ gm/sec.

Stack gas temperature $(T_s) = 175°c$

$\Rightarrow 175 + 273 = 448K$

Stack gas velocity $(V_s) = 8$ m/sec

barometric Pressure $(P) = 977$ miliban

Ambient Temperature $(T_a) = 30°c$

$30 + 273 = 303K$

Wind velocity $(u) = 4$ m/sec.

chimney diameter $(D) = 96\text{cm} = 0.96$ m.

It is given that the condition is for slightly unstable condition so belong to class 'C'.

(a) Effective stack Height $H = h + \Delta h$

We have to calculate for physical stack Height

$h = 74 (Q_p)^{0.27}$.

Q_p = Particulate Emission rate in Ton/hr.

Emission rate Q = 115 gm/sec.

convert it to ton/hr = 115×10^{-6} ton $\times 3600$

$= 414000 \times 10^{-6}$

$= 0.414$ ton/hr

$$h = 74 (Q_p)^{0.27}$$

$$= 74 \times (0.414)^{0.27}$$

$$= 58.32 \text{ m}.$$

Now we have to calculate Δh?

$$\Delta h = \frac{V_s D}{u} \left[1.5 + 2.68 \times 10^{-3} \, P \cdot D \times \frac{T_s - T_a}{T_s}\right]$$

$$= \frac{8 \times 0.96}{4} \left[1.5 + \underbrace{2.68 \times 10^{-3} \times 977 \times 0.96 \times \left(\frac{448-303}{448}\right)}_{0.813}\right]$$

$$= \underset{1.92 \times}{} \quad \underset{2.313}{}$$

$$1.92 \times 2.313$$

$$= 4.44 \text{ m}$$

Now the effective stack Height $H = h + \Delta h$

$$= 58.32 + 4.44$$

$$= 62.760 \text{ m}.$$

b) concn of dust at a distance 6 km down wind along the centreline of the Plume.

concn of dust at centreline of the plume can be calculated using formula ($y = 0$)

$$C_{x,0} = \frac{Q}{\pi u \sigma_y \sigma_z} \cdot e^{-\frac{1}{2}\left(H^2/\sigma_z^2\right)}$$

Here x down wind distance = 6 km

And it belongs to stability class 'c'

so from the dispersion coefficient graph the value of $\sigma_z = 300$ m

$\sigma_y = 550$ m.

$$C_{6Km,0} = \frac{115}{3.14 \times 4 \times 300 \times 550} \; \underbrace{e^{-1/2\left(\frac{62.760}{300}\right)^2}}_{0.978}$$

$= 5.54 \times 10^{-5}$

$= 5.42 \times 10^{-5}$ gm/m3

$= 54.2$ ug/m3 (Am)

(c) maxm ground level concentration and at which it will occur.

for maxm concentration the value of $\sigma_z = 0.7074$

$\sigma_z = 44.371$ m

The down wind distance at which it will occur is corresponds to σ_z from dispersion coefficient graph the down wind distance

$x = 0.7$ Km $= 700$ m

$\sigma_y = 80$ m

$$C_{max} = \frac{Q}{\pi u \sigma_y \sigma_z} e^{-1/2(H/\sigma_z)^2}$$

$$= \frac{115}{3.14 \times 4 \times 80 \times 44.37} \; \underbrace{e^{-1/2\left(\frac{62.76}{44.37}\right)^2}}_{0.367}$$

$= 0.000946$ gm/m3

$= 946$ ug/m3 Ans.

Q5 A Coal burning plant burns 24000 tons of coal / day. The Coal has a sulphur content 1.7%. The physical stack height h is 200 ft. inside diameter of stack at exit is 0.8 m, stack gas velocity is 18.3 m/sec. which leaves the chimney at a temperature of 140°c. Ambient air temperature is 28°c. The atmospheric pressure is 1000mbar and prevailing wind speed is 4.5 m/sec.

a) Calculate the effective stack height.

b) What is the maximum concentration of SO_2 at the ground level? use moderately unstable condition of plume.

c) Calculate the concentration of SO_2 at a distance of 5km away from the plant. Also how the concentration profile of SO_2 up to 3km from the chimney.

Soln: Given data: capacity of plant = 24000 TPD.

Sulphur content = 1.7%.

physical stack Height, h = 200 ft

Inside diameter of stack D_1 = 0.8 m

Stack gas velocity V_s = 18.3 m/sec.

Temperature of gas (T_s) = 140°c = 413 K.

Ambient air temperature T_a = 28°C = 301 k

Pressure P = 1000mbar

Wind speed u = 4.5 m/s.

a) Effective stack Height $H = h + \Delta h_v$

$$\Delta h_v = \frac{V_s D}{u}\left[1.5 + 2.68\times10^{-3}\times P\times D\times\left(\frac{T_s - T_a}{T_s}\right)\right]$$

$$= \frac{18.3\times0.8}{4.5}\left[1.5 + 2.68\times10^{-3}\times1000\times0.8\times\frac{413-301}{413}\right]$$

$= 6.771$ m.

Given $h = 200$ ft $= 60.96$ m.

$H = h + \Delta h_v = 60.96 + 6.771$ m $= 67.731$ m.

$= 222.2$ ft.

b) Maximum ground level concentration of SO_2

$$C_{max} = \frac{Q}{\pi u \sigma_y \sigma_z} e^{-\frac{1}{2} H^2/\sigma_z^2}$$

$\sigma_y/\sigma_z \simeq$ constant

For C_{max} $\sigma_z = 0.707\,H$

$\sigma_z = 0.707 \times 67.731$

$= 47.885$ m.

It was given that stability class is (B) [moderately unstable]
From dispersion coefficients graph corresponding σ_y value is

$\sigma_y = 77$ m

corresponding downwind distance $X = 0.43$ Km
$= 430$ m.

Now we have to calculate Emission rate (Q) of SO_2

$$\text{Sulphur content} = \frac{24000 \times 10^3}{86400} \times 0.017$$

$= 4.722$ kg/s

$= 4722.22$ gm/sec.

$$S + \frac{1}{2}O_2 \longrightarrow SO_2$$

4.722 kg S gives 9.44 kg SO_2

$Q_{SO_2} = 9444$ gm/sec.

$$C_{max} = \frac{9444}{\underbrace{3.14 \times 4.5 \times 77 \times 47.885}_{0.1812}} \underbrace{e^{-1/2\left(\frac{67.731}{47.885}\right)^2}}_{0.367}$$

$= 0.0666 \ g/m^3$

$= 66.66 \ mg/m^3$ (Ans.)

() concentration of SO_2 at 5km distance.

downward distance = 5 Km σ_z = 620 m.

for class (B) σ_y = 680 m.

$$C_{SO_2} = \frac{Q_{SO_2}}{\pi u \sigma_y \sigma_z} e^{-\frac{1}{2}\left(H^2/\sigma_z^2\right)}$$

$$= \frac{9444}{3.14 \times 4.5 \times 680 \times 620} \times e^{-\frac{1}{2}\left(\frac{67.731}{620}\right)^2}$$

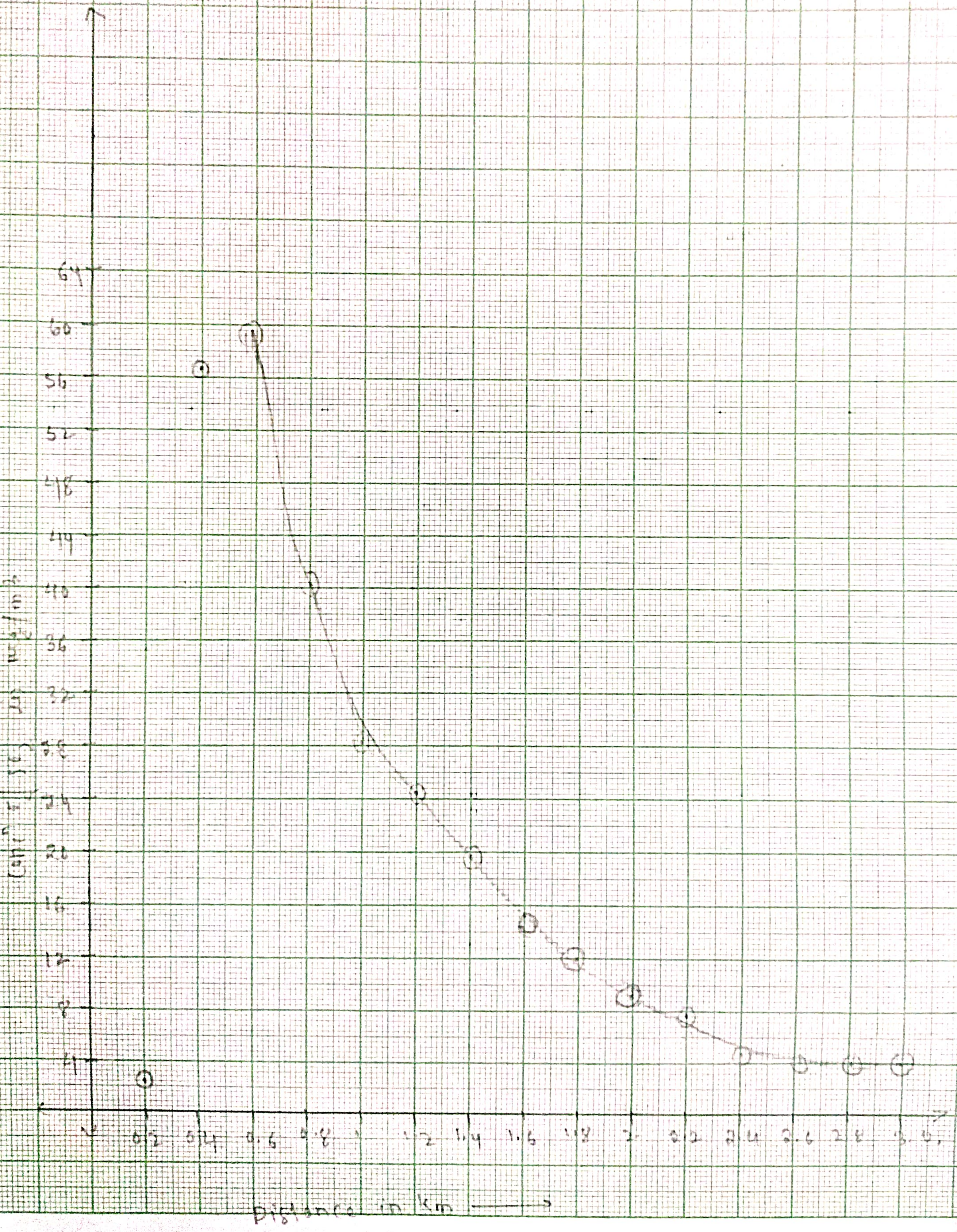
0.9940

$= 0.00157 = 1.5 \ mg/m^3$

$1.5 \ mg/m^3$.

c) show the concentration profile of SO_2 up to 3 km from Given stability class B)

S. No	Distance km	σ_y(m)	σ_z(m)	C_{SO_2} (mg/m³)
1.	0.2	38	20	2.8417
2.	0.4	70	40	56.8899
3.	0.6	100	65	59.717
4.	0.8	140	85	40.8667
5.	1.0	165	120	28.7707
6.	1.2	180	140	23.5813
7.	1.4	210	150	19.1517
8.	1.6	235	180	14.7132
9.	1.8	270	200	11.6814
10.	2.0	300	230	9.2707
11.	2.2	320	250	8.0494
12.	2.4	350	270	6.85
13.	2.6	380	300	5.7124
14.	2.8	420	320	4.86
15.	3	440	350.	4.2573.



64
60
56
52
48
44
40
36
32
28
24
20
16
12
8
4
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3
Distance in km

Q6 A 100 MW Power Plant burns 10000 tons of 1.5% S containing coal/day. The flue gases are emitted in to the atmosphere through a stack of height 200 m. and the diameter of stack at the plume exit is 0.5m. The velocity and temperature of the plume is 10 m/s and 120°c respectively at the exit. What is the down wind concentration of SO_2 in the plume centralline at a distance of 5 Km for class D plume (neutral)? Assume the ambient temperature is 15°c and wind velocity is 6 m/sec.

Sol^n Given :-

Coal burned = 10000 tones per day.

Stack Height (h) = 200 m.

Diameter of the stack = 0.5 m.

Stack velocity (V_s) = 10 m/s.

Stack exit temperature (T_s) = 120°c + 273

= 393 K

Ambient temperature (T_a) = 15°c + 273

= 288 K

Wind velocity (u) = 6 m/sec

It is given in the question that the plume is class D (Neutral) plume.

lets assume pressure (P) = 100 millibar

So calculate the effective stack Height (H)

$$H = h + \Delta h_v$$

$$\Delta h_v = \frac{V_s \cdot D}{u}\left[1.5 + 2.68 \times 10^{-3}\, P \cdot D\left(\frac{T_s - T_a}{T_s}\right)\right]$$

$$= \frac{10 \times 0.5}{6}\left[1.5 + 2.68 \times 10^{-3} \times 100 \times 0.5 \times \left(\frac{393 - 288}{393}\right)\right]$$

$$= 0.833 \times 1.535$$

$$= 1.27 \text{ m}$$

Effective stalk Height (H) = $h + \Delta hv$

$= 200 + 1.27$

$= 201.27$ m.

For calculating the downwind concentration of SO_2 in the plume centreline at a distance of 5 km $(y=0)$

$$C_{x,0} = \frac{Q}{\pi u \sigma_y \sigma_z} e^{-\frac{1}{2}\left(H^2/(\sigma_z)^2\right)}$$

we have to first calculate the emission rate Q(~~SO_2~~)

~~Su~~ Sulphur content = 10000 ton per day of 1.5% S

$$= \frac{10000 \times 10^3}{24 \times 60 \times 60} \times 0.015$$

$= 1.736$ kg/sec.

$S + \frac{1}{2} O_2 \longrightarrow SO_2$

1.736 kgs gives 3.472 kg/s

$Q_{SO_2} = 3.472$

$C_{5,0}$ = For stability class D at X = 5 km, from the dispersion coefficient graph the value of σ_y & σ_z is

$\sigma_y = 390$ m

$\sigma_z = 90$ m.

$$C_{(5000,0)} = \frac{3472}{3.14 \times 6 \times 300 \times 90} \cdot e^{-\frac{1}{2}\left(201.27/90\right)^2}$$

$= 0.000565$ gm/m3

$= 565$ ug/m3 (Am)

Q7 SO_2 is emitted through a stack 50 m Height and 2m diameter at the exit at a temperature of 120°c, with a velocity of 10 m/sec. The SO_2 emission rate is 200 g/sec. show how the ground level concentration at a down level distance of 1km varies with wind speed for stability category D when the Pressure is 100 miliban and ambient temperature is 25° c,

Soln:- Given stack Height(h) = 50 m

Stack Diameter (D) = 2m

Stack exit temperature (T_s) = 120°C + 273 = 393 K

stack gas velocity (V_s) = 10 m/sec.

Emission rate of SO_2 $Q_{(SO_2)}$ = 200 g/sec.

Pressure is (P) = 100miliban

Ambient temperature (T_a) = 25°c + 273 = 298K.

first we have to calculate effective stack Height (H)

$H = h + \Delta h_v$

$$\Delta h_v = \frac{V_s D}{u}\left[1.5 + 2.68 \times 10^{-3}\ P.D\left(\frac{T_s - T_a}{T_s}\right)\right]$$

How the ground level concentration at a down level distance of 1km varies with wind speed so we are taking wind speed of 1, 2, 4, 6, 8

If u = 1 m

$$\Delta h_v = \frac{10 \times 2}{1}\left[1.5 + 2.68 \times 10^{-3} . 100 \times 2 \times \left(\frac{393 - 298}{393}\right)\right]$$

$= 20 \times 1.629$

$= 32.58$ m.

Effective stack Height (H) = $h + \Delta h_v$
$= 50 + 32.58$
$= 82.58\,m$.

Concentration of SO_2 at a down level distance 1km.

$$C_{1000,0} = \frac{Q}{\pi u \sigma_y \sigma_z} e^{-\frac{1}{2} H^2/\sigma_z^2}$$

σ_y and σ_z at 1Km distance can be calculated from dispersion coefficient graph is

$\sigma_y = 70\,m \quad \sigma_z = 30\,m$

~~$C_{1000,0}$~~ $Q = 200\,g/sec$

$$C_{1000,0} = \frac{200}{3.14 \times 1 \times 70 \times 30} e^{-\frac{1}{2}(82.58/30)^2}$$

$= 0.000691\,gm/m^3$

$= 691\,\mu g/m^3$

If wind speed $u = 2\,m/sec$

$$\Delta h_v = \frac{V_s D}{u}\left[1.5 + 2.68 \times 10^{-3}\,P \cdot D \cdot \left(T_s - T_a/T_s\right)\right]$$

$$= \frac{10 \times 2}{2}\left[1.5 \times 2.68 \times 10^{-3} \times 100 \times 2\left(\frac{393 - 298}{393}\right)\right]$$

$= 16.29\,m$

$H = h + \Delta h_v$
$= 50 + 16.29$
$= 66.29\,m$.

$$C_{1000,0} = \frac{200}{3.14 \times 2 \times 70 \times 30} e^{-\frac{1}{2}(66.29/30)^2}$$

$= 0.001334\,gm/m^3$

$= 1334\,\mu g/m^3$ An.

If wind speed (u) = 4 m/sec.

$$\Delta hr = \frac{10 \times 2}{4}\left[1.5 + 2.68 \times 10^{-3} \times 100 \times 2 \times \left(\frac{393-298}{393}\right)\right]$$

$= 8.145$ m

$H = 50 + 8.145$

$= 58.145$

$$C_{1000,0} = \frac{200}{3.14 \times 4 \times 70 \times 30} e^{-1/2 (58.145/30)^2}$$

$= 0.001167$ gm/m3

$= 1167$ ug/m3.

If wind speed u = 6 m/sec

$$\Delta hr = \frac{10 \times 2}{6}\left[1.5 + 2.68 \times 10^{-3} \times 100 \times 2 \times \left(\frac{393-298}{393}\right)\right]$$

$= 5.43$ m

$H = 50 + 5.43 = 55.43$

$$C_{1000,0} = \frac{200}{3.14 \times 6 \times 70 \times 30} e^{-1/2 (55.43/30)^2}$$

$= 0.000914$ gm/m3

$= 914$ ug/m3

If wind speed is 8 m/se.

$$\Delta hr = \frac{10 \times 2}{8}\left[1.5 + 2.68 \times 10^{-3} \times 100 \times 2 \times \left(\frac{393-298}{393}\right)\right]$$

$= 4.07$ m

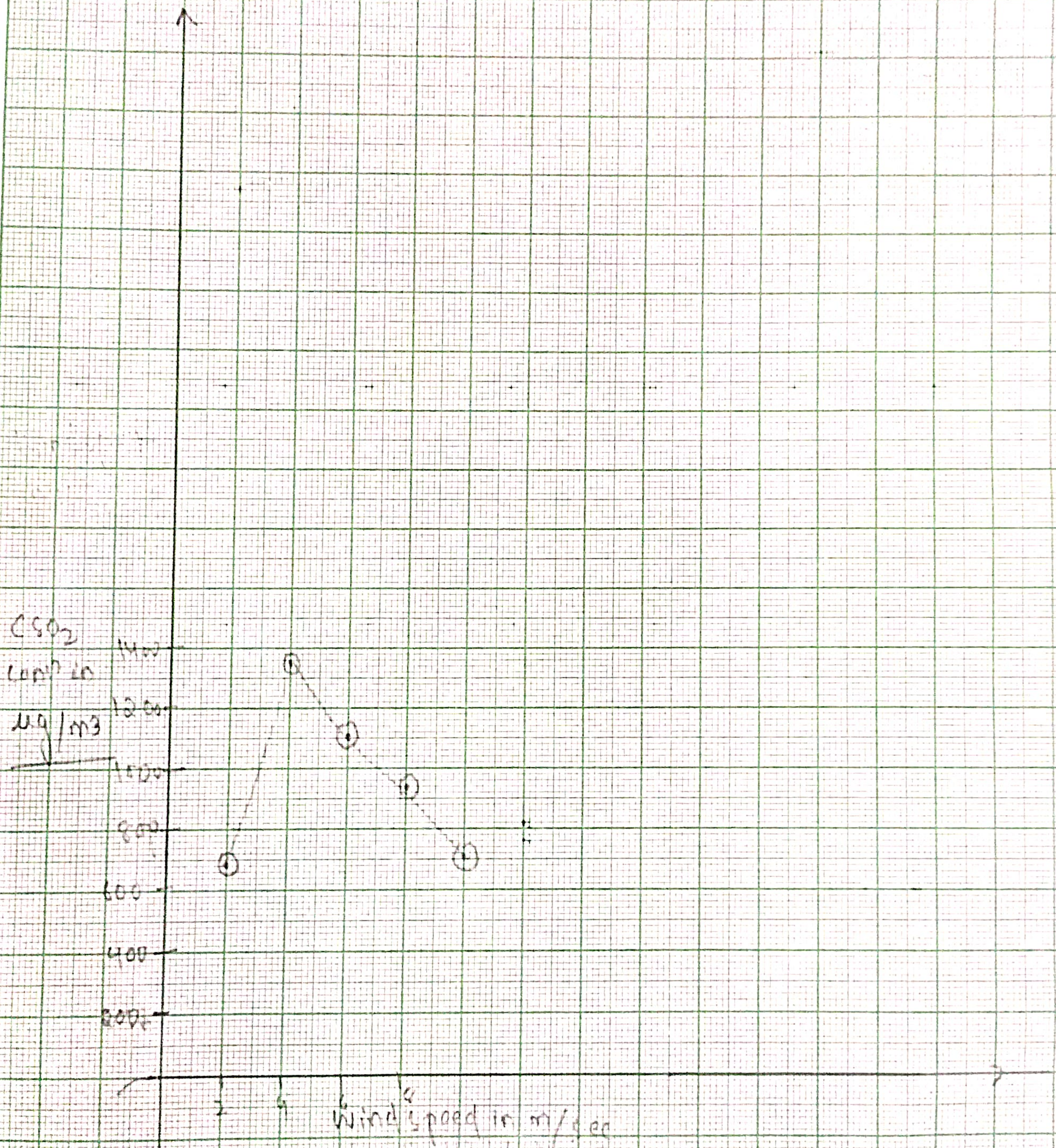
$H = 50 + 4.07$ m $= 54.07$

$$C_{1000,0} = \frac{200}{3.14 \times 8 \times 70 \times 30} e^{-1/2 (54.07/30)^2}$$

$= 0.000746$ gm/m3 $= 746$ ug/m3.

The concentration of SO_2 at downward distance of 1km varies with wind speed.

Sl.No	~~Δh~~ Wind speed m/sec.	Δh_v (m)	H (m)	$C(SO_2)$ ug/m3
1	1	32.58	82.58	691
2	2	16.29	66.29	1334
3	4	8.145	58.145	1167
4	6	5.43	55.43	914
5	8	4.07	54.07	746.



C SO2
conc in
ug/m3
1400
1200
1000
800
600
400
200
2
4
6
8
Wind speed in m/sec

Q8. A smelting plant emit SO_2 at the rate of 100kg/s and as per stringent central control board norms the maximum permissible concentration at a distance of 500 m from the stack is 80 ug/m³. Wind velocity at the top of chimney is 7.5 m/sec and the stability coefficient (down wind and cross wind) $\sigma_y = 35$ m $\sigma_z = 20$m respectively.

A) Calculate the effective stack Height if a particulate emission from the smelter plant is at the rate of 3×10^{-3} tons/hr.

calculate the minimum stack Height ?

Given:-

SO_2 emission rate $Q = 100$ Kg/s $= 1\times10^5$ g/sec.

Down wind distance $x = 500$ m

Maximum permissible ground level conc^n $C = 80$ ug/m³
$= 80\times10^{-5}$ gm/m³

wind speed (u) $= 7.5$ m/s.

dispersion coefficient $\sigma_y = 35$ m
$\sigma_z = 20$ m

effective stack Height:-

$$C_{x,0} = \frac{Q}{\pi u \sigma_y \times \sigma_z} e^{-\frac{1}{2}[H/\sigma_z]^2}$$

$$C_{5000,0} = \frac{1.0\times10^5}{3.14\times7.5\times3.5\times20} \times e^{-\frac{1}{2}[H/20]^2}$$

$$\Rightarrow 8\times10^{-5} = \frac{1.0\times10^5}{3.14\times7.5\times35\times20} \times e^{-\frac{1}{2}[H/20]^2}$$

$\boxed{H = 94.8\text{m}}$ Ans.

If the emission rate is 3×10^{3} tons / hr. = 34.72 kg/s

$$\underbrace{C_{5000,0,0}}_{8 \times 10^{-5}} = \frac{\cancel{1.0 \times 10^{5}}\ 34.72}{3.14 \times 7.5 \times 35 \times 20} e^{-1/2 [H/20]^{2}}$$

$\Rightarrow$ H =

b) Minimum stack Height

$$h = 74 (Q_p)^{0.27}$$

$$= 74 (3 \times 10^{-3})^{0.27}$$

$$\boxed{h = 15.41 m}$$

Ans.