Ref No: EX/PG/CE/T/127E/2018

Master of Civil Engineering 2nd Semester Examination 2018

Air Pollution and Control

Time: Three Hours

Full Marks: 100

(60 marks for Part 1 & 40 marks for Part 2)

Part 1

Answer **Question No. 1** and any **Two** from the rest. Turner's σ_y & σ_z curves and Pasquill's stability chart are enclosed herewith. Any relevant data may be assumed, if necessary.

1. i) Why is Gaussian Air Pollution Model (GAPM) so named?

   ii) Why is mechanical turbulence not considered in GAPM?

   iii) Mention the assumed value of 'wind shear' in GAPM.

   iv) When are both molecular and atmospheric diffusion not considered in GAPM?

   v) What is 'NNW' wind? vi) How is 'downwind' direction in GAPM selected?

   vii) How is origin of GAPM ascertained? viii) In which modified form of GAPM, σ_z is missing?

   ix) What is the coordinate of mirror image source which is assumed to accommodate 'eddy reflection'?

   x) Why are centerline modifications of GAPM important? xi) What is the full form of 'insolation'?

   xii) Which criteria air pollutant is most relevant for line source GAPM after CO?

   xiii) Which criteria air pollutant (CAP) is most reactive other than SO_2?

   xiv) Mention the correction factor of Holland's Plume Rise Model (HPRM) for neutral stability class.

   xv) What is the basic difference between HPRM and Briggs' Plume Rise Model (BPRM)?

   xvi) Define 'night' as per Pasquill Stability Class Chart.

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1. (contd...)

xvii) How many CAPs are considered in current Indian AQI method (IND-AQI)?

xviii) What may be the maximum AQI value in IND-AQI method?

xix) Which CAP is dictating currently the AQI of India (calculated by IND-AQI method)?

xx) Comment about correction of 'p' used in wind profile power law.

xxi) Define a plume.

xxii) What is the utility of X_g calculation?

xxiii) Why is σ_x missing in GAPM?

xxiv) Mention the correlation between relevant lapse rates for 'absolute stable' condition.

xxv) What is 'calm' condition?

xxvi) What may the plume patterns when inversion exists?

xxvii) When 'neutral' plume may occur?

xxviii) Which two CAPs are synergistic historically?

xxix) Define PM_{10}.

xxx) What is the main limitation of GAPM?

1X30=30

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Part 1

2. a) The general Gaussian expression is as follows:

$C_{(x,y,z;H)} = Q/(2\pi \sigma_y \sigma_z U) [Exp \{-y^2/2 \sigma_y^2\}] [Exp \{-(H-Z)^2/2 \sigma_z^2\} + Exp \{-(H+Z)^2/2 \sigma_z^2\}]$

The notations have their usual meanings. Now find expressions for following modifications

(i) receptor at ground level (GL) & $x<x_g$ (ii) receptor at GL centerline & $x< x_g$

(iii) source is at GL, receptor is at a height and $x> x_g$ (iv) receptor at plume center line and $x> x_g$

b) A stack emitting 60 g/sec of NO has an effective stack height of 80m. The wind speed at anemometer height is 4.5m/s and it is clear summer day with sun nearly overhead. Estimate the ground level NO concentration at:

(i) directly downwind at a distance 2.0 km ii) at a point (2000,200,0)

iii) at a downwind point where NO concentration is maximum

6+9= **15**

3. a) A burning solid waste dump emits 20 g/s of oxides of nitrogen (NO_x). What may be the concentration of NO_x directly downwind from the source at a distance of 3 km on an overcast night with wind speed 6m/s? The background concentration of NO_x at the receptor location is 50μg/m^3.

b) A stack with effective height 45m, emitting at the rate of 150 g/s. Winds are estimated at 5 m/s at the stack height, the stability class C, and there is an inversion at 100 m. Estimate the ground-level concentration at the point where reflections begin to occur from the inversion and at a point twice the distance downwind. What may be the type of inversion? What may be the probable plume pattern?

c) A highway has 10 vehicles per second passing a given spot, each emitting 2.13 g/km of CO. If wind is perpendicular to the highway and blowing at 2 m/s on an overcast day, estimate the ground level CO concentration 200m from the road.

4+6+5=**15**

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(60 marks for Part 1 & 40 marks for Part 2)

Part 1

Time: Three Hours

Full Marks: 100

4. Air Quality monitoring data for calculation of Air Quality Index by IND-AQI method:-

(i) Monitoring results of High Volume Sampler (with RDS attachment):

1) Initial weight of pot= 25.623gm
2) Final weight of pot= 25.859gm
3) Initial weight of filter paper=1.536gm
4) Final weight of filter paper=1.589gm
5) Average flow rate of air=1.0 m^3/min
6) Period of sampling=4hour.

(ii) Monitoring results of low volume sampler:

1) Initial weight of filter paper=0.14550gm
2) Final weight of filter paper=0.14630gm
5) Average flow rate of air=15lpm
6) Period of sampling=8hour.

(iii) Concentration of NO_2=0.05ppm

(iv) Breakpoints (in µgm/m^3) of normal AQI scale:

AQI Range	PM_{10}	$PM_{2.5}$	NO_2
0-50	0-50	0-30	0-40
51-100	51-100	31-60	41-80
101-200	101-250	61-90	81-180
201-300	251-350	91-120	181-280

Calculate AQI (show complete calculations). Comment about the result. Following equation may be needed:

$I_P = [\{(I_{HI}-I_{LO})/(B_{HI}-B_{LO})\} \times (C_P-B_{LO})] + I_{LO}$ (notations have their usual meanings) **15**

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Air Pollution and Control

(60 marks for Part 1 & 40 marks for Part 2)

Part 1

Time: Three Hours

Full Marks: 100

Some of the following equations may be required (notations have their usual meanings):

1) $\Delta h = 2.6\,(F/uS)^{1/3}$

2) $F = gr^2 v_s (1 - T_a/T_s)$

3) $S = (g/T_a)(\Delta T_a/\Delta z + 0.01°C/m)$

4) $\Delta h = [1.6F^{1/3}(x_f)^{2/3}]/u$

5) $x_f = 120\,F^{0.4}$, if $F \geq 55 m^4/s^3$

6) $x_f = 50\,(F)^{5/8}$ if $F \leq 55 m^4/s^3$

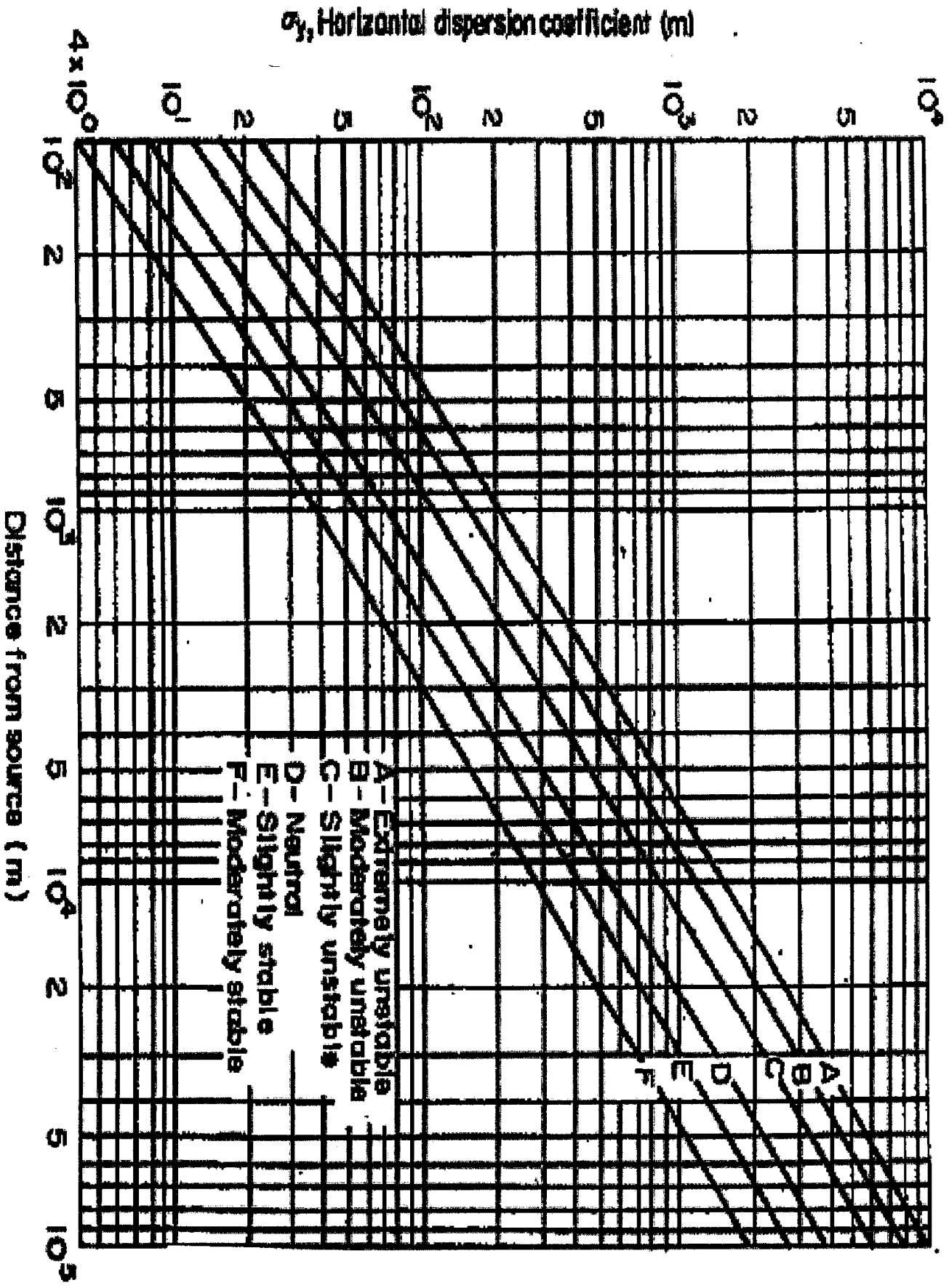
7) $C = Q / [(2\pi)^{1/2} u \sigma_y L]$

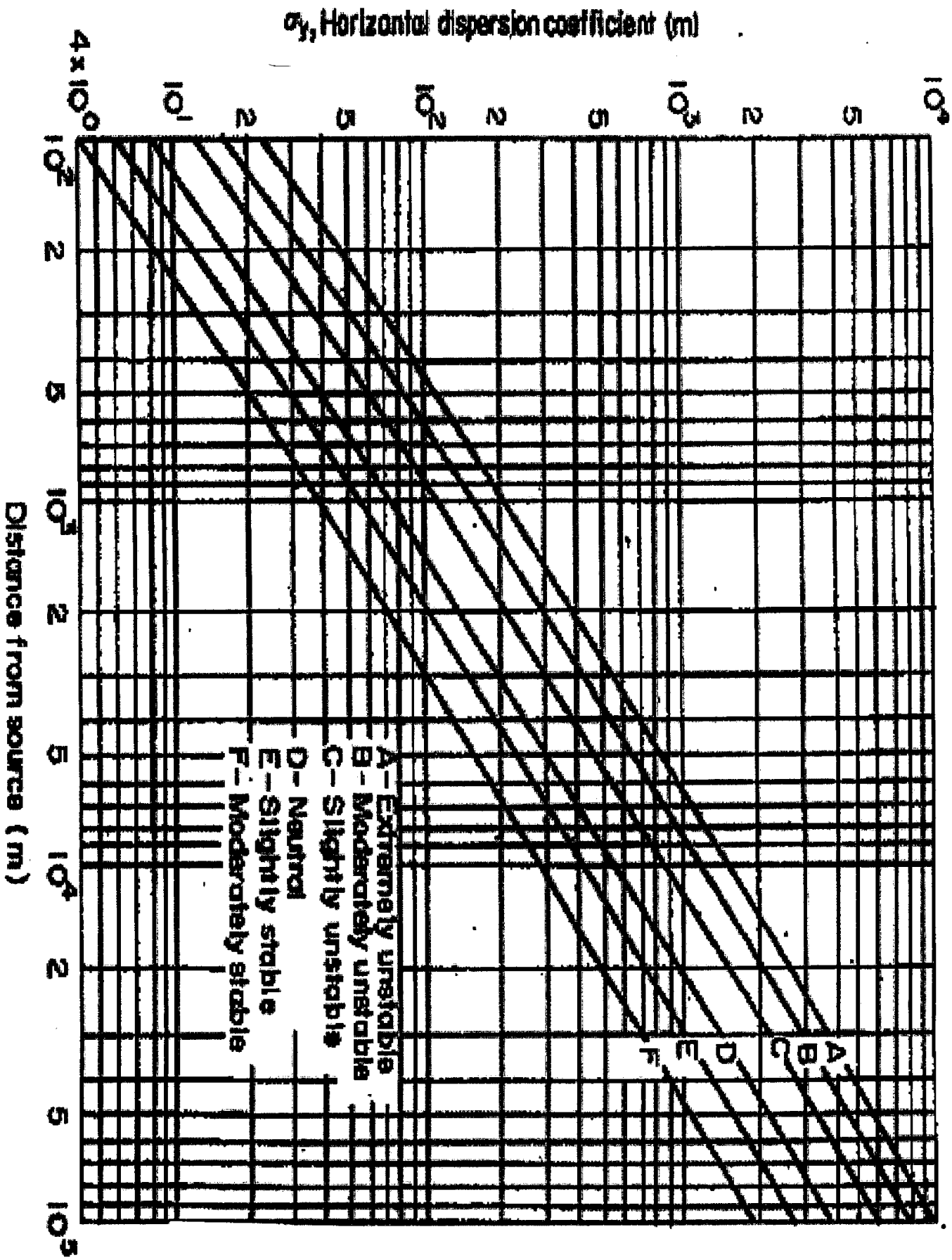
8) $\Delta h = [v_s d/u][1.5 + 2.68 \times 10^{-3} p (1 - T_a/T_s) d]$

9) $C_{(x,y,0:H)} = [2q/(2\pi)^{1/2} \sigma_z u \sin\theta][\exp(-H^2/2\sigma_z^2)]$

Table 3. Guidelines for determining Pasquill-Gifford stability classes

Surface wind speed (ms^{-1})	Day with insolation			Night	
	Strong	Moderate	Slight	Overcast or $\geq 4/8$ low low cloud	$\leq 3/8$ cloud
2	A	A–B	B	-	-
2–3	A–B	B	C	E	F
3–5	B	B–C	C	D	E
5–6	C	C–D	D	D	D
6	C	D	D	D	D


σ_y, Horizontal dispersion coefficient (m)
4×10^0
10^1
2
5
10^2
2
5
10^3
2
5
10^4
2
5
10^5
Distance from source (m)
A– Extremely unstable
B– Moderately unstable
C– Slightly unstable
D– Neutral
E– Slightly stable
F– Moderately stable
A
B
C
D
E
F


σ_y, Horizontal dispersion coefficient (m)
4×10^0
10^1
2
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10^3
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5
10^4
2
5
10^5
10^1
2
5
10^2
2
5
10^3
2
5
10^4
Distance from source (m)
A– Extremely unstable
B– Moderately unstable
C– Slightly unstable
D– Neutral
E– Slightly stable
F– Moderately stable
A
B
C
D
E
F

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M.E. CIVIL ENGINEERING 1st YEAR 2nd SEMESTER EXAMINATION, 2018

SUBJECT: AIR POLLUTION AND CONTROL (EE)

Time: Three hours

Full Marks 100
(40 marks for part II)

Use a separate Answer-Script for each part

Part-II

Question no. **1** is compulsory

Answer any **two** from the rest

(Assume any data, if required, reasonably)

(Lapple's Efficiency Curve may be used)

1.

a) What is hydro-desulfurisation of fuel oil? Describe one post-combustion regenerable wet system of flue gas desulfurisation. 5

b) What are the different types of NOx generation from furnace? Describe one NOx control strategy at the 'source'. 4

c) Mention at least five action plans in brief to minimize the air pollution of Kolkata. 3

d) Define LC_{50}, LD_{50}, 'BOD half life', and 'Hydrolysis half life'. 4

e) How the settling efficiency of Gravitational settling chamber in air pollution can be increased without changing the size of the equipment? 4

f) In a 1.6 m diameter stack, it is decided that number of sampling points will be 12. Find out the location of the sampling points. 4

2. An air stream (flue gas) with a flow rate of $6m^3/s$ is passed through a gravity settling chamber as a pretreatment, then a cyclone of standard properties. The air stream is carrying uniform particles of 10 μm diameter with a density of 1.5 g/cm^3 and a concentration of 570 $\mu g/m^3$ of flue gas. The removal efficiency of the gravity settling chamber for that diameter of particle is 25%. The diameter of the cyclone is 2 m. and the viscosity of air is 2.1×10^{-5} kg/m.s. Determine the amount of particulate removal/m^3 of flue gas (i) in gravity settling chamber (ii) in cyclone separator.

8

3. Design a parallel plate single-stage electro static precipitator (ESP) from the following data:

Required efficiency = 99.6%; Gas flow rate = 180000 m^3/hr

Particle drift velocity = 0.15 m/s; Collectrode spacing = 0.28 m $^c/_c$

Depth of collectrode = 3m; Height of collectrode = 6m; Gas flow velocity = 1.8 m/s

8

4.

(a) In a bag-house filter, the value of k_o = 33000 N.s/m^3 and k_d = 76000 s^{-1} (with usual notations). If the filter area is 8200 m^2, the air flow rate is 120 m^3/s, and the mass-volume concentration (C_{mv}) is 0.02 kg/m^3 then what will be the pressure drop through the filter (i) immediately after cleaning and (ii) after 3.2 hrs. of operation.

5

(b) What are the different types of combustion techniques adopted in air pollution control?

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