Ref No: EX/PG/CE/T/127E/2019

Master of Civil Engineering 2nd Semester Examination 2019

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 may be used. Any relevant data may be assumed, if necessary.

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

   iii) Why is mechanical turbulence not considered in GAPM?

   iv) When is turbulent diffusion neglected in GAPM?

   v) What is 'SSE' wind? vi) How is 'crosswind' direction in GAPM selected?

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

   ix) In which modified form of GAPM, σ_y is missing?

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

   xi) Why are centerline modifications of GAPM important? xii) What is 'insolation'?

   xiii) Which criteria air pollutant is most relevant for line source GAPM?

   xiv) Which criteria air pollutant (CAP) is most reactive?

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

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

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

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1. (contd...)

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

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) What is the significance of 'calm' condition for GAPMs?

xxv) What is a 'rich' air fuel ratio?

xxvi) What are three main vehicular air pollutants?

xxvii) When 'neutral' plume may occur?

xxviii) What are the vertical constraints with respect to GAPMs?

xxix) What is the correlation between σ_Z and H for C_{max} (notations have their usual meanings)?

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:

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

The notations have their usual meanings. Now find expressions for following modifications ($x > x_g$): (i) receptor is at ground level (GL) (ii) receptor is at GL centerline (iii) source & receptor both are at ground level (iv) source is at GL, receptor is at a height and (v) receptor is at plume center line

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), Comment on the result.

iii) at a downwind point where NO concentration is maximum **5+10= 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. a) If the representative formula of the hydrocarbons present in gasoline is CH_2, calculate the stoichiometric air-fuel ratio. What is the significance of the value 14.5 in this regard?

   b) Plot emission of three vehicular air pollutants vs. stoichiometric air-fuel ratio and discuss.

   c) What is a three-way catalytic convertor? Write all the three conversion equations.

   d) What is flame quenching loss? **4+5+4+2=15**

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) $\Delta h = [v_s d/u][1.5 + 2.68x10^{-3} p (1-T_a/T_s)d]$

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

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M.E. CIVIL/ENGINEERING 1st YEAR 2nd SEMESTER EXAMINATION, 2019

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 are the different types of NOx generation from furnace? Describe one NOx control strategy after its generation. 5

b) What should be the strategy of SO_2 control in a petroleum refinery? 4

c) In ambient SO_2 and NO_x measurements, what methods and chemicals are usually used? 3

d) Discuss about the 'toxicity', 'persistence', and 'bioaccumulation factor' for analyzing potential environmental impact of pollutants. 4

e) What are the different methods of wet scrubbing system of gaseous pollutants removal? 4

f) In a 1.8 m diameter stack, it is decided that number of sampling points will be 12. Find out the location of the sampling points. 4

2. The gaseous emission from a reactor is to be treated in a single cyclone separator (dry type) for removal of particulates. The particle size distribution and other relevant information are given below:

Cyclone diameter : 1.8 m; Gas viscosity : 2.4×10^{-5} kg/m.s

Particle density : 2.5 gm/cc; Gas flow rate : 6.5 m^3/s

Particle size distribution data

Particle size (μ)	0 – 5	5 – 10	10 – 20	20 – 44	44 – 64	64 – 94	94+
% by wt.	64.7	6.79	11.9	8.96	4.25	2.4	1.0

8

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

Required efficiency = 99.9%; Gas flow rate = 180000 m^3/hr

Particle drift velocity = 0.16 m/s; Collectrode spacing = 0.25 m

Depth of collectrode = 3.5 m; Height of collectrode = 7m; Gas flow velocity = 1.8 m/s

8

4.

(a) In a test for measuring k_o and k_d (with usual notations) following data are obtained:

Pressure drop after cleaning = 550 N/m^2
Pressure drop before cleaning = 2300 N/m^2
Flow rate = 0.6 m^3/s; Mass collected = 65 kg; and Filter area = 50 m^2
Determine k_o and k_d. 5

(b) Explain the significance of isokinetic sampling for SPM and SO_2 monitoring. 3