

**NATIONAL EXAMS May 2019**  
**18-Env-A5, Air Quality and Pollution Control Engineering**

**3 hours duration**

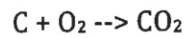
**NOTES**

1. If doubt exists as to the interpretation of any questions, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is a Closed Book Exam.
3. Candidates may use one of two calculators, the Casio or Sharp approved models. Write the name and model designation of the calculator on the first inside left hand sheet of the exam work book.
4. Question 1 and 2 must be attempted and other two (2) for a total of four (4) questions constitute a complete paper. Only the first four (4) answers as they appear in your work book(s), will be marked.
5. Each question is worth a total of 25 marks with the section marks indicated in brackets ( ) at the left margin of the question. The complete Marking Scheme is also provided on the final page. A completed exam consists of four (4) answered questions with a possible maximum score of 100 marks.

### Problem 1

Provide answers to the following questions related to *source and classifications of atmospheric pollutants, indoor and outdoor air pollutants and health and ecological impacts*.

- (20) (i) List five (5) different types of outdoor air pollutants then describe:
- their source of origin;
  - their potential health impacts; and
  - briefly explain engineering methods, one per pollutant, to reduce their potential health impacts.
- (5) (ii) For a typical plant 5, 000 MW which consumes approximately 60,000 US tons of coal per day calculate air required for combustion due to energy generation. State all assumptions.



## Problem 2

Provide answers to the following questions related to influence of solar radiation and wind fields on stack plumes, dispersion and deposition modelling of atmospheric pollutants and Eddy and Gaussian diffusion models.

(10) (i) Consider the Gaussian Plume model used to determine pollutant concentration.

$$C_x = \left( \frac{Q}{\pi \sigma_y \sigma_z u} \right) \times \exp\left(\frac{-y^2}{2\sigma_y^2}\right) \times \left\{ \exp\left(\frac{-(z-H)^2}{2\sigma_z^2}\right) + \exp\left(\frac{-(z+H)^2}{2\sigma_z^2}\right) \right\}$$

a) write simplified equation;

b) explain significance of effective stack height, provide one (1) factors that contribute to it.

c) describe how does the temperature and velocity impact the height of the plume.

(10) (ii) chose four (4) distinct type of plume behavior and for each draw a simple diagram (i.e. side view), describe the behavior in terms of distance away from the stack and dispersion. Describe potential problems with the dispersion. Assume, for prevailing wind speed  $u \gg 0$  m/s.

**Distinct type of plume behaviors:** Fumigation, Trapping, Lofting, Fanning, Coning, Looping

(5) (iii) list two (2) and describe differences in how dispersion modelling of atmospheric pollutants is handled by Gaussian and Langrangian models.

### Problem 3

Provide answers to the following questions related to *measurement techniques of air pollutants, characteristics of various air pollutant particulates and health and aesthetic considerations of PM<sub>2.5</sub> and PM<sub>10</sub>*.

- (10) (i) List two (2) measurement techniques. Describe in detail how each technique works, for which pollutant it should be used and what are the limitations and advantages of each.
- (10) (ii) a) what is total suspended particulate matter?  
b) What is condensable and filterable particulate matter? Provide examples of condensable and filterable particulate matter.  
c) What is secondary particulate matter? Provide examples.
- (5) (iii) Define PM<sub>2.5</sub> and PM<sub>10</sub>. Describe two (2) key differences in the health effects and aesthetics between the PM<sub>2.5</sub> and PM<sub>10</sub> categories of particulate pollutants.

#### Problem 4

Provide answers to the following questions related to *air toxics, mobile sources of air pollutants, noxious pollutants and odour control*.

(10) (i) Define air toxics? List three (3) air toxics and describe their sources.

(10) (ii) a) What is odour? What are units of odour?

b) Describe the type of technology that can be used for the control of emissions from this industry. List three (3) fundamental principles of the design.

c) Describe an industry which is expected to release odour.

(5) (iii) Define noxious pollutants ? list two (2) noxious pollutants and their source of emission?

### Problem 5

Provide answers to the following questions related to *control of sulphur oxides and oxides of nitrogen, desulphurization and kinetics of NO<sub>x</sub> formation and the role of nitrogen and hydrocarbons in photochemical reactions.*

- (5) (i) What is smog? Describe how is it formed and from what? List two (2), smog causing chemicals.
- (10) (iii) Provide a simple schematic and briefly describe how a commonly used Flue Gas Desulfurization plant works.
- (10) (iv) For each of: adsorption, absorption, combustion and incineration.
- a) provide definition;
  - b) Provide example when the mechanisms would be applied.