NATIONAL EXAMS DECEMBER 2015

04-Env-A5, Air Quality and Pollution Control Engineering

3 hours duration

NOTES

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is a Closed Book Exam with a candidate prepared $8\frac{1}{2}''$ x $11''$ double sided Aid-Sheet allowed.

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. Any five (5) questions constitute a complete paper. Only the first five (5) answers as they appear in your work book(s) will be marked.

5. Each question is worth a total of 20 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 five (5) 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*.

(6) (i) Explain the main difference between primary and secondary atmospheric pollutants, give an example of each type and explain how these are formed when burning coal for electric power generation.

(7) (ii) Give an example of a chemical and a biological source of indoor air pollutant (2 different pollutants). For each air pollutant, identify a potential health impact and describe two (2) potential engineering remedies to reduce this impact.

(7) (iii) Consider the indoor release of argon (Ar) and describe two (2) related health impacts. Explain one potential engineering solution to this problem.

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*.

(6) (i) Explain one (1) main difference between a buoyant plume, a dense gas plume and a passive or neutral plume. In your explanation give three (3) environmental condition when each-type of plume will dominate over the other two.

(6) (ii) Briefly explain how the Pasquill atmospheric stability classes are used in predicting the fate of atmospheric pollutants when using Gaussian or Eddy diffusion models.

(8) (iii) Consider the Gaussian model (below) used to determine the maximum ground level pollutant concentration. Identify the two (2) most important parameters in predicting ground level concentrations and explain why these two parameters are the most important.

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

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* $PM_{2.5}$ *and* PM_{10}.

(8) (i) Explain the main principle, one (1) advantage and one (1) limitation of nondispersive infrared absorption, gas chromatography or detector tube method in the measurement of one (1) air pollutant type. Select only one method and air pollutant type.

(6) (ii) Aside from particulate size, provide and explain one (1) biological, chemical and physical characteristic of air particulate pollutants that make them potentially dangerous to humans. A total of three (3) characteristics one (1) of each type is to be discussed.

(6) (iii) Compare and contrast the health effects and aesthetics between the $PM_{2.5}$ and PM_{10} categories of particulate pollutants. In your answer provide the main difference and similarity.

Problem 4

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

(8) (i) Air toxics are typically referred to as 'hazardous air pollutants' and have national ambient air standards. Give two (2) examples of hazardous air pollutants, briefly explain how their respective ambient air standards may be determined and how regulators enforce these standards.

(6) (ii) In the brewing and food industry hydrogen sulfide (H_2S) is one of the major noxious pollutants that needs to be controlled. Give an example of an odour control technology and explain the key engineering design strategy to ensure adequate odour control.

(6) (iii) Emission trading or 'cap and trade' has been identified as a useful method to control transborder air pollution. Briefly explain how emission trading works and how it may reduce the greenhouse gas emissions coming from the U.S.A. border states into Canada and vise versa.

Problem 5

Provide answers to the following questions related to *behaviour of gaseous pollutants (CO, SOx, NOx, etc.) in the atmosphere* and *monitoring and control of particulate emissions*.

(8) (i) Briefly explain how ambient temperature, atmospheric stability and mixing height affect the dispersion of air pollutants. Use equations and diagrams as necessary.

(7) (ii) Explain how the collection efficiency of a cyclonic collector is related to the particle size and how this information is used to ensure the efficient reduction of particulates over a range of particle sizes.

(5) (iii) The Deutsch-Anderson equation is commonly used to determine the extend of particle capture in electrostatic precipitators given below. Explain the significance of any three (3) parameters.

$$\eta = 1 - e^{-\omega \frac{A}{G}}$$

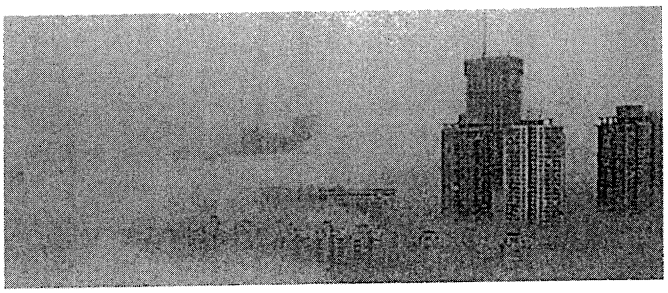
Problem 6

Provide answers to the following questions related to *control of sulfur oxides and oxides of nitrogen, desulfurisation and kinetics of NO_x formation* and *the role of nitrogen and hydrocarbons in photochemical reactions*.

(7) (i) Explain the two (2) primary methods to reduce NO_x emissions from combustion and give one (1) advantage and one (1) disadvantage of each method.

(6) (ii) Explain a technique used for desulfurisation and explain two (2) reasons why it is important to remove sulfur from petroleum or gasoline fuels.

(7) (iii) Give three (2) major photochemical reactions that involve nitrogen and hydrocarbons and briefly explain how environmental conditions contribute to smog formation.



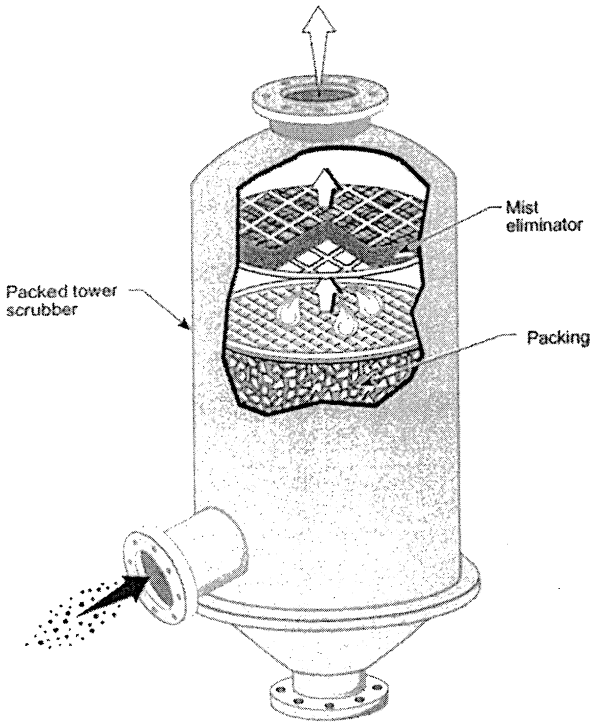
Problem 7

Provide answers to the following questions related to *control of gases and vapour emissions to the atmosphere* and *control mechanisms including adsorption, absorption, combustion and incineration.*

(6) (i) Absorption equipment is commonly used to remove SO_2 from boiler flue gas. Briefly explain the main principle of how absorption equipment works. Also explain the main difference between a physical and chemical based adsorption system.

(8) (ii) Explain how gas adsorption can be carried out in packed scrubbers or towers, to reduce emissions. In your answer explain one (1) important maintenance item to ensure the efficient operation over a long term operational period.

(6) (iii) Incinerators are often installed to ensure regulatory compliance from curing ovens that emit various toxic solvents. Briefly explain two (2) important operating principles of incinerators and the main difference between a thermal and catalytic incinerator.



Marking Scheme

1. (i) 6 (ii) 7 (iii) 7 marks, 20 marks total

2. (i) 6 (ii) 6 (iii) 8 marks, 20 marks total

3. (i) 8 (ii) 6 (iii) 6 marks, 20 marks total

4. (i) 8 (ii) 6 (iii) 6 marks, 20 marks total

5. (i) 8 (ii) 7 (iii) 5 marks, 20 marks total

6. (i) 7 (ii) 6 (iii) 7 marks, 20 marks total

7. (i) 6 (ii) 8 (iii) 6 marks, 20 marks total