
NATIONAL EXAMS MAY 2011

04-Env-A1, Principles of Environmental 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 *8.5in x 11in* 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 questions constitute a complete paper. Only the first five answers, to the seven questions, as they appear in your answer book(s) will be marked.
5. Each question is worth a total of 20 marks with the section marks indicated in square brackets [] at the end 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.

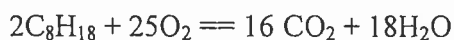
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1. Provide answers to the following questions related to population, economic growth, industrialization, urbanization and energy use as causes of environmental pollution.

Environmental pollution is one of the serious problems faced by people in highly populated and rapidly developing countries like India and China. Rapid population growth, industrialization and urbanization in a country tend to adversely affect the environment unless adequate controls are put in place through environmental legislation to promote conservation and “green” technologies. However the relationships that include economic issues are often complex and difficult to control but need resolution because they may also have adverse effects on people. In answering the questions below consider the issues provided above:

- i) Briefly explain, using an example, how urban intensification, due to population growth and relocation may cause two (2) environmental pollution problems and suggest (2) different approaches to reduce or stop such environmental pollution. [5]
- ii) Explain how economic growth does not necessarily lead to an increase in environmental pollution. In your explanation, provide two (2) necessary criteria to ensure this. [5]
- iii) Briefly explain why population control is not sufficient to eliminate an increase in environmental pollution. Give two (2) other necessary criteria. [5]
- iv) Population intensification through growth in urban centres is a common phenomenon in China and India. Explain how this may lead to improved economies and reduced environmental pollution compared to urban sprawl. [5]

2. Provide answers to the following questions related to material and energy balance for engineering systems under steady state and unsteady state conditions.

- i) An automobile driven by an internal combustion engine burns 10 kmol of gasoline consisting of 100% octane (C_8H_{18}) and converts it completely to carbon dioxide (CO_2) and water vapour by a combustion reaction, represented by the stoichiometric equation,

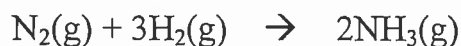


All CO_2 and H_2O produced in the reaction are discharged to the atmosphere via the engine's exhaust pipe (i.e. zero accumulation). Assume CO_2 content of input combustion air is negligible. What is the amount of carbon dioxide (in kg) discharged to the atmosphere from the burning of 10 kmol of octane? [8]

- ii) Consider the carbonate system in a fresh water lake including the air-water-limestone interphase. Briefly describe the response of the lake to an alkali spill in the lake and how the carbonate system works to buffer the pH change. In your description, consider using relevant equations and schematics. [6]
- iii) Provide an example of an environmental system in an unsteady state, a general expression to evaluate the energy balance and a simple sketch of the system showing the energy balance terms. [6]

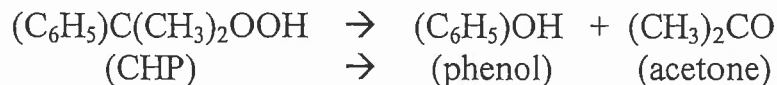
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3. Provide answers to the following questions related to the application of technical and non-technical environmental principles of solid waste management, environmental impact assessment and environmental ethics:
- Briefly describe three (3) solid waste management (SWM) practices normally adopted in developed countries as part of good environmental practice. [6]
 - An environmental impact assessment (EIA) is important to identify the critical environmental issues during the construction of a new gold mine, nuclear plant or automobile highway system. Briefly describe four (3) steps to conduct an EIA for any one of the above facilities. In your description, identify a situation where environmental ethics would play an important role during the EIA. [8]
 - Taking into account environmental ethics, briefly discuss how engineers should intervene when unsustainable engineering practices are used in developing countries in an effort to remain true to good engineering principles. [6]
4. Provide answers to the following questions related to contaminant partitioning in water with solids, chemistry of species in equilibrium and reactor material balances:

- How organic contaminants partition among the solid and liquid phases in natural environments is crucial to predicting how far they will migrate and in selecting remediation techniques. Explain how one can predict the concentration of a given contaminant in subsurface (i.e., soil-water environment). In your explanation, you should identify the important chemical and in-situ factors. [6]
- At 200°C, the $K_{eq} = 700$ for the conversion of nitrogen gas to ammonia as given below :



If the equilibrium concentration of $\text{N}_2(\text{g}) = 0.030 \text{ M}$, and $\text{NH}_3(\text{g}) = 0.12 \text{ M}$, what is the equilibrium concentration of $\text{H}_2(\text{g})$. [7]

- Consider the reaction of cumene hydro peroxide (CHP) to phenol and acetone:



Assume that the reaction is pseudo first-order and follows the rate equation below:

$$r = k \cdot C_{\text{CHP}}$$

Find the reactor volume to achieve 90% conversion of CHP at steady state, given that the flow rate into a CSTR is $Q = 30 \text{ m}^3/\text{h}$ and $k = 4 \text{ h}^{-1}$. [7]

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5. Provide answers to the following questions related to disinfection reaction kinetics, environmental ecology and water or wastewater treatment principles:
- i) Batch experiments were conducted to test the effectiveness of chlorine to reduce the *Giardia lamblia* counts in final sewage effluent. The results of the test showed that a $C \cdot t_c$ value of 80 min· mg/L was sufficient to achieve a 2-log reduction.
 - a) If Chick's law applies to the tests (recall Chick's law: $N/N_o = e^{-kt}$), what value of k corresponds to a chlorine concentration of 1 mg/L? [3]
 - b) At a chlorine dose of 2 mg/L and a contact time of 30 minutes, what fraction of *Giardia lamblia* organisms would be killed? [3]
 - ii) Select any two (2) of the five key concepts of ecological engineering (below) and briefly explain their importance in maintaining a sustainable environment when developing engineered systems that interact closely with the environment: [8]
 - (1) Ecological engineering is based on the self-designing capacity of ecosystems;
 - (2) it can be a field test of ecological theory;
 - (3) it relies on integrated system approaches;
 - (4) it conserves non-renewable energy, and
 - (5) it supports biological conservation.
 - iii) Consider a typical water treatment plant or wastewater treatment plant and briefly explain one (1) method used to separate solids from the liquid fraction. In your explanation, identify the nature of the solids, the engineering principles involved and associated equations commonly used for design. [6]
6. Provide answers to the following questions related thermal pollution, noise pollution, greenhouse gas effects and/or acid precipitation:
- i) Briefly describe three (2) potential adverse impacts and two (2) corresponding remedial solutions to alleviate the thermal impacts on water system located downstream of a cooling water discharge point associated with a nuclear generating station. [5]
 - ii) Briefly explain how material, location and dimension of noise barriers can affect their acoustical performance. [5]
 - iii) Briefly explain why CO_2 (g) and CH_4 (g) are in the top five (5) of the major greenhouse gasses. Consider the specific effects that these gases have on global warming. [5]
 - iv) Briefly explain two (2) reduction strategies used to reduce the damage caused to urban and rural landscapes (e.g., lakes, forests, masonry work) by acid precipitation. [5]

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7. Provide an answer to the following questions related to air toxics, sustainable development, life cycle analysis, principles of environmental quality objectives, standards and guidelines:

For each set of two (2) terms [(i) to (iii) below], use one (1) environmental example to briefly explain the use of the second term applied to solving environmental engineering concerns identified by the first term. *For example in i) provide an example and briefly explain how pollution control equipment can reduce the environmental problem associated with air toxics.*

- i) Air toxics and pollution control equipment; [6]
- ii) Sustainable development and environmental standards; and [7]
- iii) Achieving environmental quality objectives and life cycle analysis. [7]

Marking Scheme

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1. (i) 5 (ii) 5 (iii) 5 (iv) 5 marks; 20 marks total
2. (i) 8 (ii) 6 (iii) 6 marks; 20 marks total
3. (i) 6 (ii) 8 (iii) 6 marks; 20 marks total
4. (i) 6 (ii) 7 (iii) 7 marks; 20 marks total
5. (i) a) 3 b) 3 (ii) 8 (iii) 6 marks; 20 marks total
6. (i) 5 (ii) 5 (iii) 5 (iv) 5 marks; 20 marks total
7. (i) 6 (ii) 7 (iii) 7 marks; 20 marks total