INDIAN INSTITUTE OF TECHNOLOGY PATNA
CE 102: Environmental Studies
Final Examination 2017-18 II: EE + ME

Maximum Time: 120 Minutes **Maximum Marks: 40**

Instructions

- Answer must be *brief* and *to the point.*
- Make suitable assumptions wherever necessary.
- Numbers in the parenthesis at the end of each question indicate Maximum Marks.
- Use of notes/reference materials is *not* permitted.
- Use of mobile phone is *not* permitted. Sharing of calculator is *not* permitted.
- Write your name and roll number on the question paper in the space below before proceeding further. ***Do not forget to submit question paper along with answer book.***

Name: ______________________ **Roll No:** ______________

Questions

1. (a) Assuming ThOD is equivalent and synonymous with COD, estimate COD of 100 mg/L solution of potassium hydrogen phthalate (KHP) ($C_8H_5KO_4$).
(b) 'Removal of apparent color from water is easy as compared to true color'. Justify the statement.
(c) What is 'seeding'? Why is seeding required for BOD determination of industrial wastewater?
(d) The BOD of a sewage sample incubated for one day at 30°C has been found to be 110 mg/L. Estimate BOD_5 of the sewage sample at 20°C. Assume: (i) the value of BOD reaction constant for the sewage is known to be 0.23 per day at 20°C, and (ii) temperature characteristics term = 1.047.
(e) Stating Dalton's Law of Partial Pressure and Henry's Law, estimate Henry's Law Constant for oxygen, $(K_H)_{O_2}$ at 20°C and 30°C in atm-m^3/mol knowing equilibrium dissolved oxygen concentration in natural surface water free from pollution at 20°C and 30°C is 9.2 and 7.6 mg/L, respectively. What inferences can you draw from two values of $(K_H)_{O_2}$?
(f) Explaining the process and writing balanced equations, justify the statement showing calculation that 'nitrification process involves consumption of alkalinity of 7.14 mg as $CaCO_3$ per mg of NH_4^+-N'.

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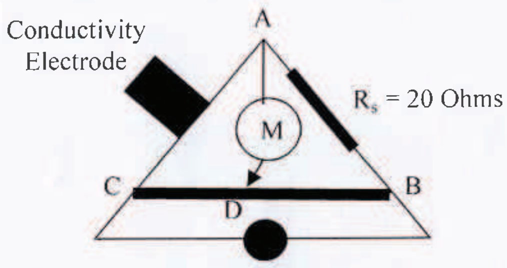
2. (a) Consider the 'Wheatstone Bridge' setup shown in the Figure below. R_S is a known resistor (20 Ohms) and R_{CB} is a linear resistor (3 Ohms/cm, 20 cm length). The conductivity electrode in the circuit consists of two metallic rectangular plates of 1 cm^2 area each, separated by a distance of 2 cm. The conductivity electrode is dipped in a water sample whose conductivity is to be measured. The pointer is slid along the linear resistor until zero current is recorded by the ammeter (M) when the pointer is at D, such that DB = 13.33 cm. Find the specific conductance of the solution in mmhos/cm.



(b) Drawing schematic/block diagram, briefly describe Phosphorous Cycle.
(c) Briefly explain ignitability and corrosivity properties of hazardous waste with examples.
(d) Drawing schematic diagram, explain the purpose and working of sanitary landfill.

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3. (a) Form the first principle i.e. classical mechanics approach, derive the following expression for the terminal settling velocity (v_t) of a particulate matter in air:

$$v_t = \frac{g}{18} \frac{(\rho_p - \rho_a)}{\mu} d_p^2$$

Here, ρ_p, ρ_a, d_p, μ and g are density of the settling particulate, density of air, diameter of the particulate, dynamic viscosity of air, and acceleration due to gravity, respectively. Clearly state the *assumptions* made while deriving the expression.

(b) Define 'aerodynamic diameter' and 'Stokes diameter'. What are basis for development of the term 'aerodynamic diameter' with respect to PM as air pollutant?

(c) Assuming airborne particles with unit density (1 g/cm^3) and diameter of (i) 0.01 μm and (ii) 10 μm, estimate terminal settling velocity for both the cases in room air in cm/s. Assume: (i) density of room air as 1.2 kg/m^3, (ii) dynamic viscosity of room air as 1.85×10^{-5} kg/m.s.

(d) Calculate the aerodynamic diameter (d_{pa}) of an airborne particle having a Stokes diameter (d_{ps}) of 2.0 μm and a density of 2700 kg/m^3.

(e) Drawing and explaining the tri-modal distribution behavior of PM, justify prevalent presence of fine or $PM_{2.5}$ in the urban atmosphere.

(f) Explain how photochemical smog is formed by drawing schematic showing source of pollutants and reactions in the atmosphere.

(g) Drawing schematic, explain how electrostatic precipitator works for removal of particulate matter.

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4. A lake is 10 m deep, well-mixed and perfectly circular with a radius of 100 m. At the inlet 2 cubic meters of water enters every second, containing 4 mg NO_3^-/L in snowmelt from the lightning-prone slopes of mountains nearby. Every day the local fisherman remove 20 kg of nitrogen (as N) from the lake in sustainable fish catches, and according to air measurements made the lake emits 500 moles of N_2O and 1000 moles of N_2 every day. There are no other sources or sinks of N. Writing appropriate mass balance equation, calculate the concentration of NO_3^- in the water coming out of the lake. Show step-by-step calculations. **(04)**

5. Draw the schematic layout/flow diagram of activated sludge process (ASP)-based Sewage Treatment Plant (STP) for treating sewage showing typical sequence of following unit operations as individual block: chlorination, sludge digester, sludge disposal, sludge thickener, equalization basin, screen chamber, grit chamber, inlet chamber, aeration tank, primary clarifier, secondary clarifier. Clearly indicate all flow streams i.e. influent, effluent, overflow, underflow, primary sludge, return activated sludge, waste activated sludge. **(03)**

Some Useful Information

C: 12; H: 1; O: 16; N: 14; S: 32; Na: 23; K: 39; Ca: 40; Mg: 24