Ref. No.: Ex/PG/ChE/T/127B/2025

M.E. CHEMICAL ENGINEERING FIRST YEAR, SECOND SEMESTER EXAM., 2025

Pollution Control and Safety in Process Industries

Time: Three Hours **Full Marks: 100**

Answer **question no. 1** and **any three (3) questions between question no. 2 to 5**

1. Answer any **five (5):** **2 x 5 = 10**

a) Discuss any one air pollution sampling method for monitoring PM as pollutant.

b) A 10 mL sample of sewage mixed with enough water to fill a 300 mL bottle has an initial DO of 9.0 mg/L. it is desired to have at least 2 mg/L drop in DO during 5 day run and final DO should be at least 2 mg/L. For what range of BOD_5 would this dilution produce the desired result.

c) Define sludge volume index (SVI) of activated sludge tank.

d) What are the effects of oxides of sulphur in air as pollutant?

e) Show the photochemical chain reactions for production of ground level ozone.

f) What are the different types of solid waste?

2.a) An ESP with 6000 m^2 of collector plate area is 97% efficient in treating 200 m^3/s of flue gas from a 200 MW power plant. How large the plate areas have to be increased to get efficiency 96% and 99%?

b) Derive the following for a centrifuge:

Where, t = minimum retention time of solid having size $>D_P$

: angular velocity

: thickness of liquid layer in centrifuge bowl

[Turn over

: radius of centrifuge bowl

c) Discuss about the head loss in a rapid sand filter.

d) In water disinfection step, free chlorine and combined chlorine are added. How and why?

10+10+5+5

3.a) Describe a Howard settling chamber

A multi-tray settling chamber handles 6 m^3/s of air at 20°C. There are 8 trays including bottom surface, spaced 0.25 m apart. The chamber is 4m long and 1m wide. For particles of density 2000 kg/m^3 and sizes (i) 70 and (ii) 25 μm, calculate the residence time, the distance settled and efficiency of collection. Is the tray spacing sufficient to collect all the particles of each size. Assume laminar flow.

b) The following results are to be used to design a setting chamber. The horizontal velocity is to be 0.3 m/s, temperature 650°C, specific gravity of particle equals 2.0 and chamber length and depth equal 7.5 m and 1.5 m, respectively. Assume that β equal to 0.9. What is the terminal settling velocity of the particle that is removed 100%?

Determine the expected percent removal of the particles?

Size (μm)	Wt (%)
0-10	8
10-20	10
20-30	12
30-40	15
40-50	19
50-60	14
60-70	13
70-80	9

15+15

4.a) A perfectly mixed aeration pond with no recycle (return line) serves as the biological reactor for a small community. The pond receives 30 m^3/d of influent with a BOD_5 of 350 mg/L that

must be reduced 20 mg/L before discharge. It has been found that the kinetic constants for the system are K_s = 100 mg/L BOD5, k_d = 0.1 d-1, μm = 1.6 d-1, and Y is 0.6 mg VSS/mg BOD_5.

i) What must the hydraulic detention time be in aeration pond?

ii) What mass of microbes will be produced in the pond each day?

b) The quantity 50 mg/L of alum is added to 50000 m^3/day of raw water containing 60 mg/L of suspended solids, 80 mg/L of Ca^{2+}, 12 mg/L of Mg^{2+} and 152.5 mg/L of HCO_3^-.

(i) Is there sufficient alkalinity in the raw water?

(ii) If not, how much should be added?

(iii) What are the daily consumption of alum and the daily production of sludge?

15+15

5.a) Short Note:

i) Different treatments and processing of solid waste

ii) Scrubbers as particulate removal device

b) A packed absorption tower is designed to remove SO_2 from a coke oven stack. The stack gas flow rate measured at 1 atm, 30°C is 10m^3/s, and SO_2 content is 3%. Using a initially pure water, 90% removal is desired. The equilibrium curve of SO_2 in water may be approximated by $y_i = 3x_i$. Determine the water requirement if 150% of the minimum flow rate is deemed adequate. Calculate the height of the tower. Assume that K_{ya} = 5.35 lbmol/ft^3-hr-Δy and K_{xa} = 117 lbmol/ft^3-hr-Δx. Assume that the total cross sectional area of the tower is 11 m^2.

10+20