Ref. No.: Ex/PG/ChE/T/127B/2024

M.E. CHEMICAL ENGINEERING FIRST YEAR, SECOND SEMESTER EXAM., 2024

Pollution Control and Safety in Process Industries

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

Answer any three (3) questions between question no. 1 to question no. 5 and answer question no. 6

1.a. Calculate initial head loss of a rapid sand filter bed for the following data using Carman-Kozeny equation. Depth of filter is 60 cm, filtration rate is 0.2 cm/s, porosity of sand is 0.4. the sphericity particle is 0.8, k =5 and kinematic viscosity is 1.01×10^{-2} cm^2/s. The sum of the ratios of fractional weight to square of diameter is 230. Derive the head loss Carman-Kozeny expression and find out the value of head loss.

b. Discuss any three air pollution sampling methods for monitoring PM as pollutant.

c. Describe the lime-soda ash method as water softening technique.

(10+8)+6+6

2.a. What is the photochemical smog? How it causes formation of peroxyacetyl nitrate (PAN)?

b. 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 98% and 99%?

c. What are the steps generally employed for pre combustion, combustion and post combustion steps to control air pollution in coal fired plants?

d. Show that hypochlorous acid is 16 times more powerful than chlorine gas as disinfectant.

3+ 10+12+5

3.a. Describe the waste treatment technology commonly employed for milk waste or tannery waste.

b. What is your idea about "circular economy"?

c. 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

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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

12+3+15

4.a. A water sample is analyzed and found to have the composition shown in the following table:

Component	Concentration
CO_2	6 mg/L
Ca^{2+}	50 mg/L
Mg^{2+}	20 mg/L
Na^{+}	5 mg/L
alkalinity	3.1 millimole/L
SO_4^{2-}	85 mg/L
pH	7.6

i) what concentrations (expressed as mg/L) of slaked lime and soda ash must be added to water to remove the maximum practical hardness?

ii) if water is the source of water for 15 MGD water softening plant, estimate the mass of sludge (kg/day) produced by the softening process.

b. Discuss the working principle of scrubbers as particulate matter (PM) removal device.

c. A multi-tray settling chamber having 8 trays including the bottom surface, handles 6 m^3/s of air at 20°C. The trays are spaced 0.25 m apart and the chamber is to be 1m wide and 4m long. What is the minimum size of particle of density 2000 kg/m^3 that can be collected with 100% efficiency? What will be the efficiency of settling chamber if 50 μm particles are to be removed? Laminar flow condition within the chamber and presence of no dust initially on trays may be assumed.

15+5+10

5.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) Estimate the collection efficiency of 75μm particle in a simple settling chamber 10 ft wide by 10 ft high by 30 ft long when the gas velocity through the chamber is 5 ft/s. Assume particle density of 120 lb_m/ft^3 and gas stream conditions of 68°F and 1 atm.

c) A conventional cyclone with diameter 1.0 m handles 3 m^3/s of standard air carrying particles with a density of 2000 kg/m^3. For N_e=6, determine the cut diameter. Given: h = 0.5 m and b=0.25 m (standard symbols).

16+8+6

6. Answer any **four (4):** **2.5 x 4 = 10**

a) What are the different types of solid waste?

b) Discuss sloughing and ponding in trickling filter.

c) Short note: Incineration

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

e) 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.

f) What are the sources of lead in air as pollutant and their effects?

g) What are the industrial dry methods for desulphurization of flue gases?