INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

End-Autumn Semester Examination 2024

Date of Examination:21-11-2024 Session: (FN) Duration: 3 Hrs Full Marks: 100

Subject No. : CH 62007 Subject : Industrial Pollution Control

Department: Chemical Engineering Graph Paper required

Answer all the questions (Assume suitable data whenever necessary with proper justification). Answer all parts of a question continuously and not in different places.

1. a) Explain the mechanism of particle charging in ESP and how efficiency of ESP related to such mechanism? How the different factors affects the performance of ESP?

b) An ESP having dimension as 4 m high, 5 m depth with spacing between the plates as 40 cm separate dust from a flue gas at a temperature of 175 ^{o}C and 1.01 kg/cm^2. The gas flows through the precipitator at a rate of 250000 m^3/hr where a voltage is varying as

$V_s = (4s^3 + 2.5) \times 10^5$ volt , where s is the spacing between discharge and collecting electrodes.

The particle size analysis shows the following distribution

Dp(Micron)	0.5	1	2	4	5	10	20
% Wight	5	22	27	23	8	4	Rest

Assume diffusional mechanism predominates the particle charging. C= 1.0 + 0.172/dp, where dp is particle dia in micron.

Calculate :

i) Particle migration velocity

ii) Overall collection efficiency of ESP

iii) if spacing is increased by 5 cm what would be % change in overall collection efficiency keeping all other parameters constant?

iv) Draw the migration velocity profile across the entire size range of particle.

[5 + 15 = 20]

2. a) Explain the cleaning mechanism of Bag filters. What are the challenges faced by industry using bag houses over other conventional techniques? Explain

b) A bag filter is operating at constant rate on an optimum cycle. The filtration equation is

$$V_G^2 = 2.623 \times 10^6 \times t \times P^{0.65}$$

where V_G =volume filtered , m^3 t= time, min and P= pressure ,cm of water

The filtering time is 45 min with a maximum allowable pressure of 10.0 cm of water. Calculate

i) Maximum overall capacity

ii) It is necessary to increase the capacity of the filter. It has been suggested that two additional unit identical to the present one be installed. All units would work from the same compressor which have ample capacity, and filtration would be carried out to the same maximum pressure as at present. The total time required to shake and clean two units is estimated at 10.0 min. What is the maximum percentage increase in the overall capacity that could be attained by adopting this suggestion?

c) Derive an expression for DP_C in a conventional cyclone separator from basic force balances. What is the significance of DP_C for selecting the cyclone separator?

[3+12+ 5 = 20]

3. a) Mention five wet scrubbers that are used for controlling gaseous emission from process plants. Explain the working principle of a multi-tray type wet scrubber with design modifications for large interfacial surface area with neat schematic diagram.

b) Discuss the design procedure of a packed column to remove soluble gaseous pollutants from a polluted gas stream with design equations.

c) A chemical process plant of approx. 193 acre plant area, manufacture products which generates toxic chemicals and surface run-off water cannot be discharged without treatment as per directions of State Pollution Control Board. It is required to construct a surface run off water pond for the plant area of various types as per Table -2. The past few years rainfall data from 2020 to 2024 as recorded is provided in Table 3. Design the surface run-off water pond required for further treatment in the ETP.

Table : 1

Surface Description	C- value
Asphalt and Concrete	0.70-0.95
Roof	0.75-0.95
Woodland	0.05-0.25
Sandy soil, Flat	0.05-0.10
Heavy Soil, Flat	0.13-0.17

Table: 2

Site Description	Site Area (in acres)
Buildings	25.09
Roads/ Pavements	71.87
Woodland	37.52
Sandy soil	53.06
Heavy soil	2.87
Drainage Area	2.42

Table: 3

Year	Rainfall (mm)
April 2019 - March 2020	1989
April 2020- March 2021	1920
April 2021 - March 2022	2287
April 2022 - March 2023	1575
April 2013 - March 2024	1122

[4 + 6 + 10 = 20]

4. a) It in required to supply domestic use water from the nearest river Kangsabati to IIT Campus through pipeline. Explain the various treatment techniques involved to purify and supply the water.

b) An industrial wastewater at the rate of 150 m^3/hr is discharged and an aerated lagoon is used for its treatment. The BOD_5 of a wastewater sample is determined as 400 mg/L at 20 ^oC. The first order BOD reaction rate constant (k) is 0.23 per day and temperature coefficient θ = 1.047. What would be the BOD_{10} value if the treatment is conducted at 30 ^oC.

Calculate the efficiency of the aerated lagoon for this wastewater.

[10 + 10 = 20]

5. a) An Activated sludge plant is used for the treatment of sludge from a plant at the rate of 250 m^3/hr. The BOD_5 of the waste is 300 mg/l. The plant consists of 4 aeration tanks each of 4 m depth, 5 m wide and 25 m long. The Mixed Liquor Volatile Suspended Solids (MLVSS) Concentration is 2800 mg/l.

Calculate

i) Detention time in Hrs
ii) Volumetric organic loading
iii) Sludge loading ratio

b) Select a specific water intensive chemical process industry and show with the help of flow sheet how Zero Liquid Discharge(ZLD) is possible to achieve.

c) Explain how peak rate of surface runoff water is calculated with equations.

[8 + 7+ 5 = 20]