Marks Scored:

KATHMANDU UNIVERSITY
End Semester Examination [C]
May/June, 2019

Level : B. Tech. | Course :BIOT 204
Year : II | Semester : I
Exam Roll No. : | Time: 30 mins. | F. M. : 20
Registration No.: | Date 02 JUN 2019

SECTION "A"
[10 Q. × 1 =10 marks]

Encircle the appropriate answer.

1. The unit of mass flow rate is.....
   a. $kg/m^3$ b. $m^3/d$ c. mg/L d. kg/day

2. 50 g benzaldehyde (MW= 106.12) vapor is condensed at $179^0$C. What is the enthalpy of the liquid relative to the vapor if latent heat for condensation is -38.40 kJ $gmol^{-1}$?
   a. -203.75 kJ b. -138.177 kJ c. -0.055 kJ d. -18.09 kJ

3. Adsorption of pollutants on activated carbon is an example of.....
   a. Liquid – Gas mass transfer
   b. Liquid Solid mass transfer
   c. Liquid-Liquid mass transfer
   d. Solid Gas mass transfer

4. In a Monod Equation, the condition $S >> K_s$ yields which of the following statements?
   a. $\mu = \mu_m$
   b. $\mu = \frac{1}{2}\mu_m$
   c. $\mu = 2\mu_m$
   d. No relation exists between $\mu$ and $\mu_m$

5. Resistance that reduces the overall heat transfer coefficient due to presence of impurities is called .....:
   a. Cooling Chamber
   b. Fouling factor
   c. Thermal boundary layer
   d. nozzle

6. The equation $\frac{DV\rho}{\mu}$ is called.....
   a. Grasshof number
   b. Nusselt number
   c. Impeller Reynolds number
   d. Reynolds number

7. A fluid is a substance that.....
   a. is practically incompressible and inviscid
   b. cannot be subjected to shear force
   c. cannot remain at rest under the action of any shear force
   d. always expands until it fills any container

8. The ratio of BOD to COD is always
   a. Equal b. less than one c. more than one d. same as DO/COD

9. A fermentation tank of 1,500,000 L, fed materials enters with velocity 2 m/s through a circular hole of diameter 4 m. The mean cell resilience time is .....
   a. 1 min b. 1000 min c. 1 sec d. 0.0167 sec

10. The specific weight of the 1 L liquid of weight 7 N is ...
    a. $7\ N/m^3$ b. $700\ N/m^3$ c. $7000\ N/m^3$ d. $0.007\ N/m^3$

## SECTION "B"

[10 Q. × 1 =10 marks]

Fill in the blanks with appropriate answer.

11. In any physical process, if the parameters does not vary with time, then such condition is defined as.....

12. Mass independent properties is called .....

13. General Mass balance equation is .....

14. The mass balance equation for steady state conservative system is .....

15. In General, organic waste contains.....% of moisture.

16. CMFR stands for .....

17. The equation which represents Fourier's law is .....

18. The amount of oxygen required to oxidize the organic matter to carbon dioxide and water in acidic condition is called .....

19. The heat required to raise the temperature of 1g of pure water by $1^0$C at 1 atm pressure expressed in terms of .....

20. A fluid which obeys the relation, $\mu = \frac{\tau}{\frac{du}{dy}}$ is called the .....

KATHMANDU UNIVERSITY
End Semester Examination [C]
May/June, 2019

02 JUN 2019

Level : B. Tech.
Year : II
Time : 2 hrs. 30 mins.

Course : BIOT 204
Semester : I
F. M. : 55

SECTION "C"
[55 Marks]

Attempt *ALL* questions.

1.

a. The overall reaction for microbial conversion of glucose to L-glutamic acid is:

$$C_6H_{12}O_6 + NH_3 + \frac{3}{2} O_2 \longrightarrow C_5H_9NO_4 + CO_2 + H_2O$$

What mass of oxygen is required to produce 15 g glutamic acid? [3]

b. The synthesis of ammonia proceeds according to the following reaction

$$N_2 + 3\ H_2 \longrightarrow 2NH_3$$

In a given plant, 4202 kg of nitrogen and 1046 kg of hydrogen are fed to the synthesis reactor per hour. Production of pure ammonia from this reactor is 3060 kg per hour.

I. What is the limiting reactant? [2]
II. What is the percent excess reactant? [2]

2. Corn-steep liquor contains 2.5 % invert sugar and 50% water; the rest can be considered solids. Beet molasses containing 50% Sucrose, 1% invert sugar, 18% water and the remainder solids, is mixed with corn steep liquor in a mixing tank. Water is added to produce a diluted sugar mixture containing 2% (W/W) invert sugars. 125 kg corn steep liquor and 45 kg molasses are fed into the tank. Draw a flow diagram and mention the necessary assumptions.

a. Prepare a complete mass balance table. [6]
b. What is the concentration of sucrose in the final mixture? [2]

3. Citric acid is manufactured using submerged culture of *Aspergillus niger* in a batch reactor operated at $30^0$C over a period of two days. 2500 kg Glucose and 860 kg oxygen are consumed to produce 1500 kg Citric acid, 500 kg biomass and other products. Ammonia is used as nitrogen source. Power input to the system by mechanical agitation of the broth is about 15 kW; approximately 100 kg water is evaporated over the culture period. Estimate the cooling requirements. Also draw a flow diagram and mention the necessary assumptions. The heat of reaction at $30^0$C is -460 kJ/kg. *(Use the property table for missing data.)* [7]

4.

a. Bioremediation is a method of cleaning up contaminated groundwater and soil. If a dilute solution of nutrients is pumped via a well into a closed soil layer underground at the rate of 0.036 tons/day, and a recovery well removes 0.0288 tons of depleted solution per day, answer the following questions: [2]

i. What is the system (draw a picture)?
ii. What is the value of the input (kg per hour) and output (kg per hour)?
iii. What is the value of the accumulation (kg per hour)?
iv. What assumption has to be made to answer (III)?

b. Calculate the heat value of Phenol ($C_6H_6OH$) using modified Dulong's formula. [3]

5.

a. Briefly describe five factors that affects rheology of fermentation broth. [5]
b. A fermentation broth with viscosity $10^{-2}$ Pa s and density 1000kg/m$^3$ is agitated in a 2.7 m$^3$ baffled tank using a Rushton turbine with diameter 0.5 m and stirrer speed 1 s$^{-1}$. Estimate the mixing time. [3]

6. A wastewater treatment system contains two completely mixed reactors in series, the first one has Hydraulic Retention Time ($\tau$) of 10 days and the second one has Hydraulic Retention Time ($\tau$) of 5 days. It is desired to check whether this system can meet a newly introduced regulations of 99.999% reduction of fecal coliform (overall concentration ratio is 0.001) by a first order die off. The rate constant, k, for the die off reaction has been found to be a function of Hydraulic Retention Time described by $k=0.2\tau-0.3$

i. Calculate the percentage reduction that can be achieved in existing condition? [4]
ii. If third reactor is added to obtain 99.999% reduction of fecal coliform, calculate the retention time of third reactor. [4]

7. A single-pass shell-and-tube heat exchanger is used to heat a dilute salt solution used in large scale protein chromatography. 25.5 m$^3$/hr solution passes through 42 parallel tubes insight the heat exchanger; the internal diameter of the tubes is 1.5 cm and the tube length is 4 m. The viscosity of the bulk salt solution is $10^{-3}$kg/m-s, the density is 1010 kg/ m$^3$, the average heat capacity is 4 kJ/kg-$^0$C and the thermal conductivity is 0.64 W/m-$^0$C. Calculate the heat transfer coefficient. [6]

8. Write Short notes on the following [6]

a. BOD and DO
b. Enthalpy
c. Recycle and Bypass stream

Property Table 1 Saturated water temperature table

Saturated water—Temperature table

| Temp., $T$ °C | Sat. press., $P_{sat}$ kPa | Specific volume, m³/kg: Sat. liquid, $v_f$ | Specific volume, m³/kg: Sat. vapor, $v_g$ | Internal energy, kJ/kg: Sat. liquid, $u_f$ | Internal energy, kJ/kg: Evap., $u_{fg}$ | Internal energy, kJ/kg: Sat. vapor, $u_g$ | Enthalpy, kJ/kg: Sat. liquid, $h_f$ | Enthalpy, kJ/kg: Evap., $h_{fg}$ | Enthalpy, kJ/kg: Sat. vapor, $h_g$ |
|---|---|---|---|---|---|---|---|---|---|
| 0.01 | 0.6117 | 0.001000 | 206.00 | 0.000 | 2374.9 | 2374.9 | 0.001 | 2500.9 | 2500.9 |
| 5 | 0.8725 | 0.001000 | 147.03 | 21.019 | 2360.8 | 2381.8 | 21.020 | 2489.1 | 2510.1 |
| 10 | 1.2281 | 0.001000 | 106.32 | 42.020 | 2346.6 | 2388.7 | 42.022 | 2477.2 | 2519.2 |
| 15 | 1.7057 | 0.001001 | 77.885 | 62.980 | 2332.5 | 2395.5 | 62.982 | 2465.4 | 2528.3 |
| 20 | 2.3392 | 0.001002 | 57.762 | 83.913 | 2318.4 | 2402.3 | 83.915 | 2453.5 | 2537.4 |
| 25 | 3.1698 | 0.001003 | 43.340 | 104.83 | 2304.3 | 2409.1 | 104.83 | 2441.7 | 2546.5 |
| 30 | 4.2469 | 0.001004 | 32.879 | 125.73 | 2290.2 | 2415.9 | 125.74 | 2429.8 | 2555.6 |
| 35 | 5.6291 | 0.001006 | 25.205 | 146.63 | 2276.0 | 2422.7 | 146.64 | 2417.9 | 2564.6 |
| 40 | 7.3851 | 0.001008 | 19.515 | 167.53 | 2261.9 | 2429.4 | 167.53 | 2406.0 | 2573.5 |
| 45 | 9.5953 | 0.001010 | 15.251 | 188.43 | 2247.7 | 2436.1 | 188.44 | 2394.0 | 2582.4 |
| 50 | 12.352 | 0.001012 | 12.026 | 209.33 | 2233.4 | 2442.7 | 209.34 | 2382.0 | 2591.3 |
| 55 | 15.763 | 0.001015 | 9.5639 | 230.24 | 2219.1 | 2449.3 | 230.26 | 2369.8 | 2600.1 |
| 60 | 19.947 | 0.001017 | 7.6670 | 251.16 | 2204.7 | 2455.9 | 251.18 | 2357.7 | 2608.8 |
| 65 | 25.043 | 0.001020 | 6.1935 | 272.09 | 2190.3 | 2462.4 | 272.12 | 2345.4 | 2617.5 |
| 70 | 31.202 | 0.001023 | 5.0396 | 293.04 | 2175.8 | 2468.9 | 293.07 | 2333.0 | 2626.1 |
| 75 | 38.597 | 0.001026 | 4.1291 | 313.99 | 2161.3 | 2475.3 | 314.03 | 2320.6 | 2634.6 |
| 80 | 47.416 | 0.001029 | 3.4053 | 334.97 | 2146.6 | 2481.6 | 335.02 | 2308.0 | 2643.0 |
| 85 | 57.868 | 0.001032 | 2.8261 | 355.96 | 2131.9 | 2487.8 | 356.02 | 2295.3 | 2651.4 |
| 90 | 70.183 | 0.001036 | 2.3593 | 376.97 | 2117.0 | 2494.0 | 377.04 | 2282.5 | 2659.6 |
| 95 | 84.609 | 0.001040 | 1.9808 | 398.00 | 2102.0 | 2500.1 | 398.09 | 2269.6 | 2667.6 |

## References

$P_r$ = Prandtl Number = $C_p\mu_b/k_{fb}$

$N_u = 0.023\ R_e^{0.8} P_r^{0.4}$

Where the symbol have usual meaning and is valid for the following conditions

$10^4 \leq R_e \leq 1.2 \times 10^5$ (turbulent flow), $0.7 \leq P_r \leq 120$ and $\frac{L}{D} \geq 60$