Marks Scored:

KATHMANDU UNIVERSITY
End Semester Examination
February/March, 2019

Level : B. Tech.
Year : II

Course : BIOT 204
Semester : I

Exam Roll No. :

Time: 30 mins.

F. M. : 20

Registration No.:

Date FEB 25 2019

SECTION "A"

[10 Q. × 1 =10 marks]

Tick (√) the appropriate answer.

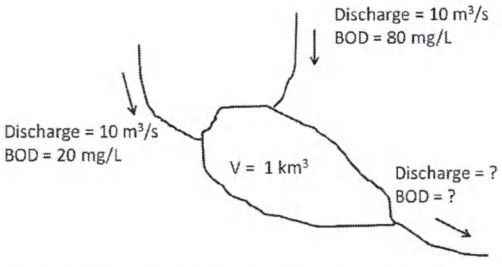
1. The unit of thermal conductivity is.....
   a. W $m^{-2}\,{}^0C^{-1}$ b. W $m^{-1}\,{}^0C^{-1}$ c. W $m^{-2}\,{}^0C^{-2}$ d. W $m^{-1}\,K^{-1}$

2. 50 g benzaldehyde (MW= 106.12) vapor is condensed at 179^0C. 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. Which of the following is not related to kinetics of bacterial growth?
   a. Michaelis-Menten equation b. Modified Dulong's formula
   c. Modified-Gompertz model d. Monod equation

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 μ and μ_m

5. The output BOD in the figure shown below is:
   a. 50 mg/L b. 5 mg/L c. 60 mg/L d. 100 mg/L



6. Which of the following statement is correct.
   a. BOD increases with increase in DO b. BOD and DO are always equal
   c. BOD increases with decrease in DO d. BOD and DO are independent to each other

7. Which of the following fluids obeys Newton's law of viscosity?
   a. Blood b. Rubber solutions c. Sugar solution d. Alcohol

8. Organic waste contains ..... moisture.
   a. 50-60% b. 10-15% c. 1-5% d. 100%

9. 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. 7000 N/m^3

10. The density for the same liquid (Question no. 9) is .....
a. 713.5 kg/ m^3 b. 71.35 kg/ m^3 c.7135 kg/ m^3 d. 0.7135 kg/ m^3

SECTION "B"

[10 Q × 1=10 marks]

Fill in the blanks with appropriate answer.

11. The product of volumetric flow rate and concentration is called.....

12. A parameter used to characterize the type fluid flow is called .....

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

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

15. The fluid which follows Newton's law of viscosity is called .....fluid.

16. CSTR stands for .....

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

18. Mean cell resilience time (θ) is defined as .....

19. The heat required to raise the temperature of 1g of pure water by 1^0C at 1 atm pressure is called .....

20. Resistance factor that reduces the overall heat transfer coefficient is called .....

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SECTION "C"
[55 Marks]

Attempt *ALL* questions.

1. a. Define Recycle, Bypass and purge stream with flow diagram. [3]
   b. The relationship between growth rate constant and limiting substrate concentration in mixed culture is given by Monod Equation. Determine the value of μ when $S >> Ks$, $Ks >> S$ and $S = Ks$ and explain the significance of these conditions with diagram. [3]

2. A Distillation column separates 10,000 kg/hr of a 50% benzene and 50% toluene mixture. The Product D recovered from the condenser at the top of the column contains 95% benzene and the bottom W from the column contains 96% toulene. The vapor stream V entering the condenser from the top of the column is 8000 kg/hr. A portion of the product from the condenser is returned to the column as reflux, and the rest is withdrawn elsewhere. Assume that the compositions of the streams at the top of the column V, the product withdrawn D and the reflux R are identical because V stream is condensed completely. Find the ratio of the amount Refluxed R to the product withdrawn D. [6]

3. *Acetobacter aceti* bacteria convert ethanol to acetic acid under aerobic conditions. A continuous fermentation process for vinegar production is proposed using non-viable *A. aceti* cells immobilized on the surface of gelatin beads. The production target is 2 kg/hr acetic acid; however the maximum acetic acid concentration tolerated by the cells is 12%. Air is pumped into fermenter at a rate of 200 gmol/hr. (Draw a flow diagram and mention the necessary assumptions.)
   a. What minimum amount of ethanol is required? [2]
   b. What minimum amount of water must be used to dilute the ethanol to avoid acid inhibition? [2]
   c. What is the composition of the fermenter off gas? [2]

4. a. Calculate the heat value of ethanol (CH_3CH_2OH) using modified Dulong's formula. [3]
   b. Fumaric acid is produced from malic acid using the enzyme, fumarase. Calculate the standard heat of reaction for the following enzyme conversion.

$$C_4H_6O_5 \longrightarrow C_4H_4O_4 + H_2O$$

The Standard heat of combustion for the Fumaric Acid is -1334 kJ / gmol and for the malic acid is -1328.8 kJ / gmol. [3]

5. a. 1 kg of soil sample was analyzed and found to contain 5.0 mg fertilizer. What is the fertilizer concentration in mg/L and ppm? [2]
   b. Water at 25^0C enters an open heating tank at a rate of 10 kg/hr. Liquid water leaves the tank at 88^0C at a rate of 9 kg/hr. 1 kg/hr water vapor is lost from the system through evaporation. At steady state, what is the rate of heat input to the system? *(Use the property table for missing data.)* [6]

6. a. Define Viscosity. State and explain the Newton's Law of Viscosity. [2]

b. If the velocity of distribution over a plate is given by $u = \frac{2}{3}y - y^2$ in which u is the velocity in m/s at a distance y meters above the plate, determine the shear stress at y=0 and y=0.15 m. Take dynamic viscosity of fluid as 8.63 poise. [3]

c. 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]

7. A wastewater treatment system contains two completely mixed reactors in series, the first one has Hydraulic Retention Time (τ) of 10 days and the second one has Hydraulic Retention Time (τ) 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]

8. A fermenter used for antibiotic production must be maintained at 27^{0}C. Based on the oxygen demand of the organism and the heat dissipation from the stirrer, the maximum heat transfer rate required is estimated as 550 kW. Cooling water is available at 10^{0}C. The exit temperature of cooling water is 25^{0}C.The heat transfer coefficient for fermentation broth and cooling water is 2150 W m^{-2} ^{0}C^{-1} and 14000 W m^{-2} ^{0}C^{-1} respectively. It is proposed to install a helical cooling coil inside the fermenter; the outer diameter of the coil pipe is 8 cm; the pipe thickness is 5 mm and the thermal conductivity of the steel is 60 W m^{-1} ^{0}C^{-1}. An average internal fouling factor of 8500 W m^{-2} ^{0}C^{-1} is expected; the fermenter side surface of the coil is kept relatively clean. What length of cooling coil is required? [7]

FEB 2 5 2019

Property Table 1 Saturated water temperature table

Saturated water—Temperature table

		Specific volume, m^3/kg		Internal energy, kJ/kg			Enthalpy, kJ/kg			Entropy, kJ/kg·K		
Temp., T °C	Sat. press., P_{sat} kPa	Sat. liquid, v_f	Sat. vapor, v_g	Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
0.01	0.6117	0.001000	206.00	0.000	2374.9	2374.9	0.001	2500.9	2500.9	0.0000	9.1556	9.1556
5	0.8725	0.001000	147.03	21.019	2360.8	2381.8	21.020	2489.1	2510.1	0.0763	8.9487	9.0249
10	1.2281	0.001000	106.32	42.020	2346.6	2388.7	42.022	2477.2	2519.2	0.1511	8.7488	8.8999
15	1.7057	0.001001	77.885	62.980	2332.5	2395.5	62.982	2465.4	2528.3	0.2245	8.5559	8.7803
20	2.3392	0.001002	57.762	83.913	2318.4	2402.3	83.915	2453.5	2537.4	0.2965	8.3696	8.6661
25	3.1698	0.001003	43.340	104.83	2304.3	2409.1	104.83	2441.7	2546.5	0.3672	8.1895	8.5567
30	4.2469	0.001004	32.879	125.73	2290.2	2415.9	125.74	2429.8	2555.6	0.4368	8.0152	8.4520
35	5.6291	0.001006	25.205	146.63	2276.0	2422.7	146.64	2417.9	2564.6	0.5051	7.8466	8.3517
40	7.3851	0.001008	19.515	167.53	2261.9	2429.4	167.53	2406.0	2573.5	0.5724	7.6832	8.2556
45	9.5953	0.001010	15.251	188.43	2247.7	2436.1	188.44	2394.0	2582.4	0.6386	7.5247	8.1633
50	12.352	0.001012	12.026	209.33	2233.4	2442.7	209.34	2382.0	2591.3	0.7038	7.3710	8.0748
55	15.763	0.001015	9.5639	230.24	2219.1	2449.3	230.26	2369.8	2600.1	0.7680	7.2218	7.9898
60	19.947	0.001017	7.6670	251.16	2204.7	2455.9	251.18	2357.7	2608.8	0.8313	7.0769	7.9082
65	25.043	0.001020	6.1935	272.09	2190.3	2462.4	272.12	2345.4	2617.5	0.8937	6.9360	7.8296
70	31.202	0.001023	5.0396	293.04	2175.8	2468.9	293.07	2333.0	2626.1	0.9551	6.7989	7.7540
75	38.597	0.001026	4.1291	313.99	2161.3	2475.3	314.03	2320.6	2634.6	1.0158	6.6655	7.6812
80	47.416	0.001029	3.4053	334.97	2146.6	2481.6	335.02	2308.0	2643.0	1.0756	6.5355	7.6111
85	57.868	0.001032	2.8261	355.96	2131.9	2487.8	356.02	2295.3	2651.4	1.1346	6.4089	7.5435
90	70.183	0.001036	2.3593	376.97	2117.0	2494.0	377.04	2282.5	2659.6	1.1929	6.2853	7.4782
95	84.609	0.001040	1.9808	398.00	2102.0	2500.1	398.09	2269.6	2667.6	1.2504	6.1647	7.4151
100	101.42	0.001043	1.6720	419.06	2087.0	2506.0	419.17	2256.4	2675.6	1.3072	6.0470	7.3542
105	120.90	0.001047	1.4186	440.15	2071.8	2511.9	440.28	2243.1	2683.4	1.3634	5.9319	7.2952
110	143.38	0.001052	1.2094	461.27	2056.4	2517.7	461.42	2229.7	2691.1	1.4188	5.8193	7.2382
115	169.18	0.001056	1.0360	482.42	2040.9	2523.3	482.59	2216.0	2698.6	1.4737	5.7092	7.1829
120	198.67	0.001060	0.89133	503.60	2025.3	2528.9	503.81	2202.1	2706.0	1.5279	5.6013	7.1292
125	232.23	0.001065	0.77012	524.83	2009.5	2534.3	525.07	2188.1	2713.1	1.5816	5.4956	7.0771
130	270.28	0.001070	0.66808	546.10	1993.4	2539.5	546.38	2173.7	2720.1	1.6346	5.3919	7.0265
135	313.22	0.001075	0.58179	567.41	1977.3	2544.7	567.75	2159.1	2726.9	1.6872	5.2901	6.9773
140	361.53	0.001080	0.50850	588.77	1960.9	2549.6	589.16	2144.3	2733.5	1.7392	5.1901	6.9294
145	415.68	0.001085	0.44600	610.19	1944.2	2554.4	610.64	2129.2	2739.8	1.7908	5.0919	6.8827
150	476.16	0.001091	0.39248	631.66	1927.4	2559.1	632.18	2113.8	2745.9	1.8418	4.9953	6.8371
155	543.49	0.001096	0.34648	653.19	1910.3	2563.5	653.79	2098.0	2751.8	1.8924	4.9002	6.7927
160	618.23	0.001102	0.30680	674.79	1893.0	2567.8	675.47	2082.0	2757.5	1.9426	4.8066	6.7492
165	700.93	0.001108	0.27244	696.46	1875.4	2571.9	697.24	2065.6	2762.8	1.9923	4.7143	6.7067
170	792.18	0.001114	0.24260	718.20	1857.5	2575.7	719.08	2048.8	2767.9	2.0417	4.6233	6.6650
175	892.60	0.001121	0.21659	740.02	1839.4	2579.4	741.02	2031.7	2772.7	2.0906	4.5335	6.6242
180	1002.8	0.001127	0.19384	761.92	1820.9	2582.8	763.05	2014.2	2777.2	2.1392	4.4448	6.5841
185	1123.5	0.001134	0.17390	783.91	1802.1	2586.0	785.19	1996.2	2781.4	2.1875	4.3572	6.5447
190	1255.2	0.001141	0.15636	806.00	1783.0	2589.0	807.43	1977.9	2785.3	2.2355	4.2705	6.5059
195	1398.8	0.001149	0.14089	828.18	1763.6	2591.7	829.78	1959.0	2788.8	2.2831	4.1847	6.4678
200	1554.9	0.001157	0.12721	850.46	1743.7	2594.2	852.26	1939.8	2792.0	2.3305	4.0997	6.4302