



B.TECH. DEGREE EXAMINATIONS: APRIL / MAY 2023

(Regulation 2018)

Third Semester

BIOTECHNOLOGY

U18BTT3102: Bioprocess Calculations

COURSE OUTCOMES

- CO1:** Apply the unit conversion and basic calculations.
CO2: Solve the material balance without and with involving chemical reactions.
CO3: Analyze the energy balance involving chemical reactions.
CO4: Conceptualize energy balance without involving chemical reactions.
CO5: Elucidate the concept of thermodynamic preliminaries.
CO6: Elaborate the stoichiometry for growth and product formation.

Time: Three Hours

Maximum Marks: 100

Answer all the Questions

PART A (10 x 2 = 20 Marks)

(Answer not more than 40 words)

- | | | |
|---|-----|-------------------|
| 1. The superficial mass velocity is found to be 200 lb/hr ft ² . Find its equivalent in kg/s.m ² | CO1 | [K ₂] |
| 2. What is the volume of 25 kg of chlorine at standard condition? | CO1 | [K ₂] |
| 3. Recall about the recycle and bypass. | CO2 | [K ₁] |
| 4. Define selectivity and percentage yield. | CO2 | [K ₁] |
| 5. Estimate the standard heat of reaction ΔH_{298}° for the reaction.
A + B → C Standards heats of combustion are:
$\Delta H_{c,298}$ for A = - 328000 cal/g
$\Delta H_{c,298}$ for B = - 212000 cal/g
$\Delta H_{c,298}$ for C = - 542000 cal/g | CO3 | [K ₃] |
| 6. What is the change in the enthalpy of 100 g/s acid heated in a double pipe heat exchanger from 20°C to 80°C, if the average heat capacity at constant pressure is 0.50 cal/g °C? | CO4 | [K ₃] |
| 7. Outline the following process:
(i) Isochoric
(ii) Isobaric
(iii) Isothermal
(iv) Adiabatic | CO5 | [K ₁] |
| 8. Distinguish between homogeneous and heterogeneous system. | CO5 | [K ₂] |

9. What is meant by respiratory quotient? CO6 [K₁]
10. Recall steady state and unsteady state with its equation. CO6 [K₁]

Answer any FIVE Questions
PART B (5 x 4 = 20 Marks)
(Answer not more than 80 words)

11. A solution of naphthalene in benzene contains 25 mol % Naphthalene. Express the composition in weight %. CO1 [K₃]
12. A single effect evaporator concentrating a weak liquor containing 5% solids to 55% solids (by weight) is fed with 6000 kg/h of weak liquor. Calculate the amount of water evaporated per hour and flow rate of thick liquor. CO2 [K₃]
13. Differentiate between the sensible heat and latent heat. CO3 [K₂]
14. Calculate enthalpy change for one mole of a gas when it is heated from 400 K to 1500 K at 1 atm pressure given that the mean specific heat of the gas at the reference temperature of 273 K are 35 kJ/k mol K at 400 K and 50 kJ/k mol K at 1500 K. CO4 [K₃]
15. A system consisting of some fluid is stirred in a tank. The rate of work done on the system by the stirrer is 2.25 hp. The heat generated due to stirring is dissipated to the surroundings. If the heat transferred to the surroundings is 3400 kJ/h, determine the change in internal energy. CO5 [K₃]
16. Production of single cell proteins from hexadecane is given by the following equation. If respiratory quotient (RQ) is 0.4, determine the stoichiometric coefficients. CO6 [K₄]



Answer any FIVE Questions
PART C (5 x 12 = 60 Marks)
(Answer not more than 300 words)

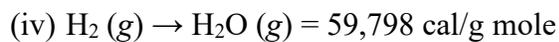
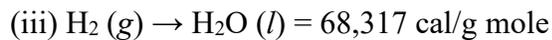
17. a) A gaseous mixture analyzing CH₄: 10%, C₂H₆: 30% and rest H₂ at 15 °C and 1.5 atm is flowing through an equipment at the rate of 2.5 m³/min. Find (i) the average molecular weight of the gas mixture, (ii) weight % and (iii) the mass flow rate. 6 CO1 [K₃]
- b) Using Rayleigh's method, show that the resistance force R of a partially submerged body in water can be expressed in the form. 6 CO1 [K₄]

$$R = \rho l^2 v^2 \phi \left[\frac{\mu}{lV\rho}, \frac{lg}{V^2} \right]$$

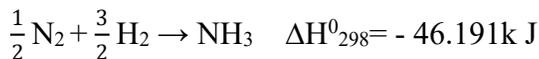
18. a) 100 kg mol/h of 40 mole% of solution of Ethylene dichloride in Toluene is fed to middle of the distillation column. The distillate contains 95 mole% Ethylene dichloride and the bottoms consists of 90 mole% Toluene. What is the rate of flow of each stream? 6 CO2 [K₃]

b) The following data were obtained in a test on a coal fired steam generator. The ultimate analysis of coal: C, 80.5%; H, 4.6%; O, 5.0%; N, 1.1%; ash, 8.8%. No carbon is lost in the refuse. The Orsat analysis of flue gas: CO₂, 16.4%; O₂, 2.3%; CO, 0.4%; N₂, 80.9%. Calculate the weight of dry gaseous products formed per 100 kg of coal fired. 6 CO2 [K4]

19. Using the following data of heats of combustion in cal/g mole, calculate the heat of vaporization of benzene. 12 CO3 [K3]



20. Ammonia is synthesized according to the following reaction: 12 CO4 [K4]



The specific heats are represented by

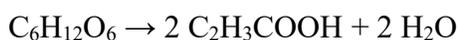
$C_p = \alpha + \beta T + \gamma T^2$ where C_p is in J/mol K and α , β and γ are:

Compounds	α	β	γ
N ₂	27.31	5.2335×10^{-3}	-4.1868×10^{-9}
H ₂	29.09	-8.374×10^{-4}	2.0139×10^{-6}
NH ₃	25.48	36.89×10^{-3}	-6.305×10^{-6}

Determine the heat of the reaction at 700 K.

21. Make use of mnemonic diagram and derive the Maxwell's equations. 12 CO5 [K3]

22. A bioreactor was charged with 5000 kg/h of an aqueous solution of fermented grain containing 15% by weight glucose (C₆H₁₂O₆). Yeast digests the glucose to form ethanol and acrylic acid (C₂H₃COOH). 12 CO6 [K3]



If 150 kg CO₂ is produced and 110 kg unreacted glucose remains in the broth, determine the percent composition by weight of the products in the broth.
