Reg. No. ☐☐☐☐☐☐☐☐☐☐☐☐☐

B.TECH. DEGREE EXAMINATION, MAY 2023

Fourth Semester

BT18403 – THERMODYNAMICS FOR BIOTECHNOLOGISTS

(Biotechnology)

(Regulation 2018)

TIME: 3 HOURS   MAX. MARKS: 100

CO 1 Summarize the theoretical concepts of thermodynamics and how it applies to energy conversion in technological applications and biological systems

CO 2 Identify the capability to analyze the energy conversion performance in a variety of modern applications in biological systems.

CO 3 Identify the criteria when two phases coexist in equilibrium and the vapour liquid equilibrium calculations.

CO 4 Compare the criteria when chemical reaction tends to attain chemical reaction equilibrium.

CO 5 Design and carry out bioprocess engineering experiments, and analyze and interpret fundamental data to do the design and operation of bioprocesses, microbial growth and product formation.

PART- A (10 x 2 = 20 Marks)

(Answer all Questions)

		CO	RBT LEVEL
1.	What is the significance of Mollier diagram?	1	1
2.	Estimate the coefficient of performance of an ideal Carnot engine operating between a temperature limit of 280 K and 320 K.	1	2
3.	Distinguish molar volume and partial molar volume	2	2
4.	State Lewis Randall rule.	2	1
5.	Define modified Raoult's law.	3	2
6.	Define fugacity and fugacity coefficient.	3	2
7.	What is the relation about Gibbs free energy and standard heat of reaction & equilibrium constant?	4	1
8.	What is extent of reaction?	4	1
9.	What is the importance of $\Delta_R G^O$ values?	5	1
10.	What do you mean by basal metabolic rate?	5	1

PART- B (5 x 14 = 70 Marks)

		Marks	CO	RBT LEVEL
11. (a)	Derive Maxwell equations and also mention the applications.	(14)	1	3

(OR)

(b)	(i)	Derive PVT relationships for Adiabatic process.	(7)	1	3
	(ii)	Derive Joule Thomson Coefficient for Vanderwaals equation of state.	(7)	1	3

12. (a)	(i)	Define chemical potential. Derive the expressions for the effect of temperature and pressure on chemical potential.	(8)	2	3
	(ii)	Explain the tangent-intercept method for determination of partial molar properties.	(6)	2	3

(OR)

(b)	At 300 K and 1 bar, the volumetric data for a liquid mixture of benzene and cyclohexane are represented by	(14)	2	3

$$V = 109.4 \times 10^{-6} – 16.8 \times 10^{-6}x – 2.64 \times 10^{-6}x^2,$$

where x is the mole fraction of benzene and V has the units of m3/mol. Find expressions for the partial molar volumes of benzene and cyclohexane.

13. (a)	(i)	Explain the criterion of Phase equilibria.	(4)	3	4
	(ii)	Explain the phase diagrams of liquid-liquid equilibrium.	(10)	3	4

(OR)

(b)	(i)	Distinguish the types of azeotropes with an example.	(4)	3	4
	(ii)	From vapour–liquid equilibrium measurements for ethanol–benzene system at 318 K and 40.25 kPa it is found that the vapour in equilibrium with a liquid containing 38.4% (mol) benzene contained 56.6% (mol) benzene. The system forms an azeotrope at 318 K. At this temperature, the vapour pressures of ethanol and benzene are 22.9 and 29.6 kPa respectively. Determine the composition and total pressure of the azeotrope. Assume that van Laar equation is applicable for the system.	(10)	3	4

14. (a)	A mixture of 1 mol CO and 1 mol water vapour is undergoing the water-gas shift reaction at a temperature of 1100K and pressure of 1 bar.	(14)	4	4

$$CO(g) + H_2O(G) \rightarrow CO_2 + H_2(g)$$

The equilibrium constant for the reaction is K=1. Assume that the gas mixture behaves as ideal gas. Calculate

    (i) The fractional dissociation of steam.

    (ii) The fractional dissociation of steam if the reactant stream is diluted with 2 mol nitrogen.

(OR)

(b)	**(i)**	Explain the criteria of Chemical Reaction Equilibria.	**(4)**	**4**	**4**
	(ii)	Explain the effect of temperature and pressure on equilibrium constant. Also derive the effect of pressure on equilibrium composition.	**(10)**	**3**	**4**

15. (a)		Explain about the Herbert model, Pirt model and Compromise model of microbial maintenance in detail.	**(14)**	**3**	**5**

(OR)

(b)	**(i)**	Explain about the non-growth components for microbial maintenance.	**(6)**	**3**	**5**
	(ii)	Classify the microbial product formation. Mention with examples.	**(8)**	**3**	**5**

PART- C (1 x 10 = 10 Marks)
(Q.No.16 is compulsory)

		Marks	CO	RBT LEVEL
16.	Water (i)- hydrazine (ii) system forms an azeotrope containing 58.5% (mol) hydrazine at 393°K and 101.3 Kpa. Calculate the equilibrium vapour composition for a solution containing 20% (mol) hydrazine. The relative volatility of water with reference to hydrazine is 1.6 and may be assumed to remain constant in the temperature range involved. The vapour pressure of hydrazine at 393°K is 124.76 KPa.	**(10)**	**3**	**5**