Reg.No.:												

VIVEKANANDHA COLLEGE OF ENGINEERING FOR WOMEN
[AUTONOMOUS INSTITUTION AFFILIATED TO ANNA UNIVERSITY, CHENNAI]
Elayampalayam – 637 205, Tiruchengode, Namakkal Dt., Tamil Nadu.

Question Paper Code: 90014

B.E. / B.Tech. DEGREE END-SEMESTER EXAMINATIONS – NOV. / DEC. 2025
Third Semester
Biotechnology
U23BT304 – THERMODYNAMICS FOR BIOTECHNOLOGISTS
(Regulation 2023)

Time: Three Hours | Maximum: 100 Marks

Answer ALL the questions

Knowledge Levels (KL)	K1 – Remembering	K3 – Applying	K5 - Evaluating
	K2 – Understanding	K4 – Analyzing	K6 - Creating

PART – A

(10 x 2 = 20 Marks)

Q.No.	Questions	Marks	KL	CO
1.	Relate enthalpy change to internal energy.	2	K1	CO1
2.	Mention any two examples of high-energy biomolecules.	2	K1	CO1
3.	State the relation between activity and fugacity.	2	K1	CO2
4.	Write the Gibbs–Duhem equation for a binary solution.	2	K2	CO2
5.	Predict how heat capacity varies with temperature for liquids and gases.	2	K2	CO3
6.	Determine the type of heat effect involved in converting ice at 0 °C to steam at 100 °C.	2	K2	CO3
7.	Recall the expression of Maxwell relation for an ideal gas.	2	K1	CO4
8.	State the third law of thermodynamics.	2	K1	CO4
9.	Infer the role of energy coupling in ATP synthesis.	2	K2	CO5
10.	State how heat generation occurs during aerobic microbial growth.	2	K1	CO5

PART – B

(5 x 13 = 65 Marks)

Q.No.		Questions	Marks	KL	CO
11.	a)	State and describe the fundamental laws of thermodynamics with suitable examples.	13	K1	CO1

(OR)

	b)	List the different types of thermodynamic energy terms and outline their roles in biochemical systems.	13	K1	CO1
12.	a)	Discuss the significance of partial molar properties and show how they are used to describe solution behavior.	13	K2	CO2
		(OR)			
	b)	Explain the concepts of chemical potential and activity coefficients, and relate them through the Gibbs–Duhem equation.	13	K2	CO2
13.	a)	One kmol of methane is burned with 100 % excess air at 298 K and 1 atm. Assuming complete combustion and that all products are in the gaseous state at 298 K, i. Calculate the standard heat of reaction using the following data (in kJ mol^{-1}): ΔH_f^0 (CH_4) = −74.8 ΔH_f^0(CO_2) = −393.5 ΔH_f^0(H_2O)g = −241.8 ii. Determine also the heat released per kmol of CH_4 burned.	13	K4	CO3
		(OR)			
	b)	A bioreactor operates at 310 K. During an aerobic oxidation, the following stoichiometric reaction occurs: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ Given standard heats of formation (kJ mol^{-1}): ΔH_f^0 ($C_6H_{12}O_6$) = −1273 ΔH_f^0 (CO_2) = −393.5 ΔH_f^0 ($H_2O_{(l)}$) = −285.8 Calculate the heat evolved during the oxidation of 1 mol of glucose and discuss its industrial relevance.	13	K4	CO3
14.	a)	Using thermodynamic relations, analyze the enthalpy and entropy changes for 2 moles of an ideal gas expanding isothermally from 5 L to 20 L at 300 K.	13	K3	CO4
		(OR)			
	b)	For an ideal gas, show how enthalpy and entropy change during an adiabatic expansion, and calculate the final temperature, if 1 mole of gas expands from 10 L to 20 L.	13	K3	CO4
15.	a)	Describe the thermodynamic principles governing metabolic pathways and illustrate with an example of glycolysis.	13	K2	CO5
		(OR)			

Q.No.	Questions	Marks	KL	CO
b)	Discuss the energetics of DNA–protein interactions and explain how thermodynamic parameters determine binding stability.	13	K2	CO5

PART – C

(1 x 15 = 15 Marks)

Q.No.		Questions	Marks	KL	CO
16.	a)	During aerobic growth of bacteria, explain how heat is generated and why oxygen is required. Suggest one simple method to remove excess heat.	15	K2	CO3
		(OR)			
	b)	Explain ATP energy coupling in a simple biochemical reaction and how it helps drive an otherwise non-spontaneous reaction.	15	K2	CO5