Q. Code:203374

Reg. No. | | | | | | | | | | | | | |

B.E. / B. TECH.DEGREE EXAMINATIONS, MAY 2024

Fourth Semester

BT22403 – CHEMICAL AND BIOCHEMICAL THERMODYNAMICS

(Biotechnology)

(Regulation 2022)

TIME:3 HOURS **MAX. MARKS: 100**

COURSE OUTCOMES	STATEMENT	RBT LEVEL
CO 1	Summarize the theoretical concepts of thermodynamics and how it applies to energy conversion in technological applications and biological systems	**3**
CO 2	Identify the capability to analyze the energy conversion performance in a variety of modern applications in biological systems	**3**
CO 3	Identify the criteria when two phases coexist in equilibrium and the vapour liquid equilibrium calculations.	**3**
CO 4	Compare the criteria when chemical reaction tends to attain chemical reaction equilibrium.	**3**
CO 5	Design and carry out bioprocess engineering experiments, and analyze and interpret fundamental data to do the design and operation of maintenance energy in microbial growth and product formation and to acquire knowledge on thermodynamic cycles	**4**

PART- A(20x2=40Marks)

(Answer all Questions)

		CO	RBT LEVEL
1.	A heat engine operates between a heat source at 700K and a heat sink at 300K. What is the maximum efficiency of the engine?	**1**	**2**
2.	What is Mollier diagram?	**1**	**2**
3.	State zeroth and third law of thermodynamics.	**1**	**2**
4.	Distinguish Vapor and Gas.	**1**	**2**
5.	What is the physical significance of chemical potential?	**2**	**2**
6.	Derive activity (a_i) of a component 'i' is equal to the product of its activity coefficient γ_i and mole fraction x_i.	**2**	**3**
7.	Distinguish between molar volume and partial molar volume.	**2**	**3**
8.	Define modified Raoult's law.	**2**	**2**
9.	Distinguish bubble point and dew point.	**3**	**3**
10.	Define modified Phase rule.	**3**	**2**
11.	What is Poynting Correction factor?	**3**	**2**
12.	Can the entropy of a system ever decrease? Why or why not?	**3**	**3**
13.	Write VantHoff equation.	**4**	**2**
14.	State Hess's Law.	**4**	**2**

15.	How does the standard heat of reaction relate to standard Gibbs-energy change of reaction?	**4**	**3**
16.	For the gas phase reaction $C_2H_4 + H_2O \rightarrow C_2H_5OH$ the equilibrium constant at 145 °C and 1 bar is $K = 6.8 \times 10^{-2}$. How would you calculate the equilibrium constant at 10 atm pressure?	**4**	**3**
17.	Define ATP yield coefficient.	**5**	**2**
18.	List the importance of $\Delta_R G^O$ values.	**5**	**3**
19.	What do you understand by Basal Metabolic Rate?	**5**	**2**
20.	Mention the expression for Gibbs energy for thermodynamics of maintenance.	**5**	**2**

PART- B (5x 10=50Marks)

		Marks	CO	RBT LEVEL
21. (a)	Show $Cp - Cv = \beta^2 VT/K$, Where $\beta = 1/V\ (dV/dT)p$ and $K = -1/V\ (dV/dP)_T$	**(10)**	**1**	**2**
	(OR)			
(b)	What is Joule Kelvin effect? Derive the expressions for Joule Thomson coefficient for Ideal gas and Vanderwaals gas.	**(10)**	**1**	**2**
22. (a)	Explain the tangent-intercept method for determination of partial molar properties.	**(10)**	**2**	**3**
	(OR)			
(b)	The enthalpy of a binary liquid system of species 1 and 2 at fixed T and P is represented by the equation. $H=400x_1+600x_2+x_1x_2(40x_1+20x_2)$ where H is in $Jmol^{-1}$. Determine expressions for H_1 and H_2 as functions of x_1 numerical values for the pure species enthalpies H_1 and H_2 and numerical values for the partial enthalpies at infinite dilution H_1^∞ and H_2^∞.	**(10)**	**2**	**3**
23. (a)	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**	**3**
	(OR)			

(b)	**(i)**	Explain the criteria for Phase equilibria.	**(2)**	**3**	**3**
	(ii)	Explain the phase diagrams of liquid-liquid equilibrium.	**(8)**	**3**	**3**

24. (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. **(10)** **4** **3**

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

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) n-Butane is isomerized to i-butane by the action of catalyst at moderate temperatures it is found that the equilibrium is attained at the following compositions. **(10)** **4** **3**

Temperature, K	Mol%, n-Butane
317	31.00
391	43.00

Assuming that activities are equal to the mole fractions, Calculate the standard free energy of the reaction at 317K and 391K and average value of heat of reaction over the temperature range.

25. (a) Calculate the stoichiometric coefficients for the following biological reactions. **(10)** **5** **3**

Hexadecane:

$C_{16}H_{34} + aO_2 + bNH_3 \rightarrow c(C_{4.4}H_{7.3}N_{0.86}O_{1.2}) + dH_2O + eCO_2$

Glucose:

$C_6H_{12}O_6 + aO_2 + bNH_3 \rightarrow C(C_{4.4}H_{7.3}N_{0.86}O_{1.2}) + dH_2O + eCO_2$

Calculate the yield coefficients $Y_{x/s}$ (g dw cells/ g substrate) $Y_{x/O2}$ (g dw cells/g O_2) for both the reactions. Comment on the differences.

(OR)

(b) Explain about the Herbert model, Pirt model and Compromise model of microbial maintenance in detail. **(10)** **5** **3**

PART- C (1x 10=10Marks)

(Q.No.26 is compulsory)

		Marks	CO	RBT LEVEL
26.	How do you assess that Carnot cycle process is an ideal cycle? Defend with suitable examples and diagrams.	**(10)**	**5**	**5**

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