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B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

September / October 2023 Supplementary Examinations

Programme: B.E. **Semester: IV**
Branch: Biotechnology **Duration: 3 hrs.**
Course Code: 19BT4ESPET **Max Marks: 100**
Course: Process Engineering Thermodynamics **Date: 21.09.2023**

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

UNIT - I

1	a)	Derive an equation for first law of thermodynamics for non- flow process.	**05**
	b)	Distinguish between reversible and irreversible processes.	**05**
	c)	Derive an equation for Clausius inequality making suitable assumptions.	**10**

OR

2	a)	A system consisting of a gas confined in a cylinder is undergoing the following series of processes before it is brought back to the initial conditions: Step 1: A constant pressure process when it receives 50 J of work and gives up 25 J of heat. Step 2: A constant volume process when it receives 75 J of heat. Step 3: An adiabatic process. (Note: In adiabatic process there is no heat exchange between system and surroundings.) Determine the change in internal energy during each step and the work done during the adiabatic process.	**10**
	b)	Derive an equation for efficiency considering ideal gas as Carnot engine working substance.	**10**

UNIT - II

3	a)	Define compressibility factor. What is the principle of corresponding state?	**05**
	b)	How do you relate Vander Waals constants to critical properties?	**05**
	c)	Calculate the compressibility factor and molar volume for methanol vapour at 500 K and 10 bar by using the following equations. Experimental values of virial coefficients are, B= -2.19×10^{-4} m^3/mol; C = -1.73×10^{-8} m^6/mol^2.The critical temperature and pressure of methanol are 512.6 K and 81 bar. (a) Truncated form of virial equation (b) Redlich–Kwong equation	**10**

UNIT - III

4	a)	Derive Gibb's Duhem's equation. Write the applications of it.	**10**
	b)	Express the partial molar property as the partial derivative of the total property of the solution. Is it intensive property or extensive property?	**04**

c) Derive Clausius Clapeyron equation. Discuss its importance. **06**

OR

5 a) Derive all the Maxwell equations from the exact differential equations of the four energy properties. **10**

b) At 200K, the compressibility factor of oxygen varies with pressure as given below. Evaluate the fugacity of oxygen at this temperature and 100 bar using graphical method. **10**

P, bar	1	4	7	10	40	70	100
Z	0.9970	0.9880	0.9788	0.9696	0.8734	0.7764	0.6871

UNIT - IV

6 a) Mixture of n-Heptane (A) and n-Octane (B) are expected to behave ideally. The total pressure over the system is 101.3kPa. Using the vapor pressure data given below: **10**

i. Construct the boiling point diagram and the equilibrium diagram.

ii. Deduce an equation for equilibrium diagram using an arithmetic mean of value.

T, K	371.4	378	383	388	393	398.6
P_A, kPa	101.3	125.3	140	160	179.9	205.3
P_B, kPa	44.4	55.6	64.5	74.8	86.6	101.3

b) How would you state the criterion of equilibrium in terms of entropy, the work function and Gibb's free energy? **05**

c) Distinguish between the bubble-point and dew-point temperatures with neat T-x,y diagram. **05**

UNIT - V

7 a) Aerobic degradation of benzoic acid by mixed culture of microorganisms is given by: **06**

$C_6H_5COOH + aO_2 + bNH_3 \rightarrow c\ (C_5H_7NO_2) + dH_2O + eCO_2$

i) Determine the coefficients a, b, c, d and e where RQ = 0.9

ii) Determine the biomass yield coefficients, $Y_{X/S}$, and Oxygen yield coefficients, Y_X/O_2 (g dw cell/ g O_2).

iii)Determine the degree of reduction for the substrate and bacteria.

b) Prove that summation of product of chemical potential and stoichiometric number is equal to zero at chemical reaction equilibria. Explain the changes in Gibbs free energy with extent of reaction for different cases with neat graph. **08**

c) What is the phase rule as applicable for reacting systems? Explain with an example. **06**

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