Ref. No. : Ex/FTBE/BS/B/T/216/2025

B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING SECOND YEAR FIRST SEMESTER – 2025

Subject : CHEMICAL ENGINEERING THERMODYNAMICS

Time: 3hr **Full Marks: 100**

Part I (Total Marks 50)

Instructions : Use Separate Answer scripts for each part

Answer any <u>five</u> questions from the following: **5x10=50**

1. a) Deduce the expression of Maxwell's relation and derive any one Maxwell's equation. 2+3=5
b) Find the expression of Joule-Thomson coefficient. 5

2. a) Define Volume expansivity (β) and Isothermal compressibility K_T.
b) For acetone at 293.15 K and 1 bar
$\beta = 1.487 \times 10^{-3}\ K^{-1}$
$K_T = 62 \times 10^{-6}\ bar^{-1}$
$V = 1.287 \times 10^{-3}\ m^3/kg$
Find
i. The value of $(\delta P/\delta T)_V$
ii. The pressure generated when acetone is heated at constant volume from 293 K and 1 bar to 303 K.
iii. The volume change when acetone is changed from 293 K and 1 bar to 273 K and 10 bar. 4+6=10

3.a) Derive Clausius –Clapeyron Equation.
b) Deduce Gibb's Duhem relations 4+6=10

4.Define
a) Chemical potential
b) Fugacity
c) Entropy
d) Gibbs free energy
e) Phase rule 2x5=10

5.What are the assumptions and limitations of Raoult's Law for Vapour/Liquid Equilibrium?
A binary system of Acetonitrile (1) / Nitromethane (2) conforms closely to Raoult's law. Vapor pressure for the pure species are given by the following Antoine equations;

$$\ln P_1^{sat}/\text{kPa} = 14.2724 - 2945.47/(T-49.15)$$
$$\ln P_2^{sat}/\text{kPa} = 14.2043 - 2972.64/(T-64.15)$$

Using the above equations fill up the following table and prepare a graph of P vs x_1 and P vs y_1 at temperature 348 K

x_1	0.00	0.20	0.40	0.60	0.80	1.00
P	?	?	?	?	?	?
y_1	?	?	?	?	?	?

4+6=10

6. Prove that
$dS = Cp.(dT/T) - R.(dP/P)$ .....equation (I)
For an ideal gas with constant heat capacities undergoing a reversible adiabatic (Isentropic) process.

$$(T_2/T_1) = (P_2/P_1)^{(\gamma-1)/\gamma}$$

Show that the same equation results from application of equation (I) with $\Delta S = 0$ 5+5=10

[Turn over

Ref. No.: Ex/FTBE/BS/B/T/216/2025

B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING THIRD YEAR FIRST SEMESTER EXAM 2025

Subject-CHEMICAL ENGINEERING THERMODYNAMICSTime- 3 hr FM-100

Part - II (50 Marks)

(Answer question no 1 and any two from the rest)

1. Discuss the working principal of two stroke engine. What are the benefits of relating COP with temperature? 6+4=10
2. How the problem of breaking turbine blade can be solve in steam power plant- discuss with PV Diagrams.Discuss the efficiency of Rankine cycle using steam with and without superheat.10+10=20
3. An air refrigeration open system operating between 0.5 MPa and 50 kPa is required to produce a cooling effect of 2000 kJ/min. the temperature of air leaving the cold chamber is -5^0 C and at leaving the cooler is 30^0C. Neglecting losses and clearance in the composure and expander, determine: a) mass of air circulated per hour, b) compressor work, expander work and the cycle work, c) coefficient of performance and the power required to run the machine.What are the different factors effects the choice of refrigerant?

   12+8=20
4. A Power generating plant uses steam as a working fluid and operates on Ranking cycle between a source temperature of 311.1^0 C (boiler pressure 100 bar) and a sink temperature of 32.9^0 C (condenser pressure 0.05 bar). (a) Determine the cycle efficiency and work ratio if all the processes are reversible. Also determine the rate of steam generation if the power output of the plant is 1 MW. (b) How the cycle efficiency and work ratio would be affected if isentropic efficiency of turbine is 0.8 and the saturated liquid coming out of the condenser is compressed to the boiler pressure with an isentropic efficiency of 0.9.

   Given data: At 311.1^0C source temperature (boiler pressure 100 bar)

   $h_1 = h_{g1} = 2727.7$ KJ/Kg

   $s_1 = s_{g1} = 5.62$ KJ/Kg

   At 32.9^0 C sink temperature (condenser pressure 0.05 bar)

   $h_f = 137.8$ KJ/Kg , $h_{fg} = 2423.7$ KJ/Kg$s_f = 0.476$ KJ/ Kg-K

   $s_{fg} = 7.919$ KJ/ Kg-K 20