



B.TECH DEGREE EXAMINATIONS: MAY 2015

(Regulation 2013)

Fourth Semester

BIOTECHNOLOGY

U13BTT405 : Chemical Engineering Thermodynamics

Time: Three Hours

Maximum Marks: 100

Answer all the Questions:-

PART A (10 x 1 = 10 Marks)

- Which is a state function?
 - Work
 - Pressure
 - Temperature
 - Specific volume
- A system, in which there is exchange of energy but not of mass, is called a/an _____ system.
- Entropy of a substance remains constant during a/an _____ change.
 - Reversible isothermal
 - Reversible adiabatic
 - Irreversible isothermal
 - Irreversible adiabatic
- At absolute zero temperature, the _____ of the gas is zero.
- For an ideal liquid solution, which of the following is unity?
 - Fugacity co-efficient
 - Activity
 - Fugacity
 - Activity co-efficient
- In a dilute solution, _____ obeys Henry's law and _____ the obeys Raoult's law.
- A system is said to be at equilibrium, if the entropy of the system has reached _____ value.
 - Maximum
 - Minimum
 - Zero
 - Infinity
- The phase rule is given as _____.
- Equilibrium constant of a reaction varies with the
 - Initial concentration
 - Pressure
 - Temperature
 - Activation energy
- The numerical value of the equilibrium constant depends upon the _____.

PART B (10 x 2 = 20 Marks)

(Not more than 40 words)

11. Distinguish between system and surroundings.
12. Define enthalpy of a system.
13. What is the difference between a vapour and a gas?
14. How do you define compressibility factor?
15. State Lewis-Randall rule.
16. List out the characteristics of an ideal solution.
17. Define bubble point and dew point.
18. What do you understand by azeotrope?
19. How is extent of reaction related to the mole fraction of the species in the reaction mixtures?
20. What is the effect of temperature on the equilibrium constant?

PART C (5 x 14 = 70 Marks)

(Not more than 400 words)

Q.No. 21 is Compulsory

21. (i) Derive the Maxwell's equations. (10)
(ii) What is their importance in establishing relationships between thermodynamic properties? (4)
22. a) (i) Calculate the entropy change when 2.0 mol of a perfect gas A and 3.0 mol of a perfect gas B mix spontaneously. (7)
(ii) A fully charged car battery gradually discharges while lying on the shelf at a constant temperature. During discharging it loses 250 kcal to the environment. The battery is then recharged slowly to its initial state. The charging process consumes 0.53 kWh of electricity. What is the heat transfer during the charging process? (7)

(OR)

- b) Heat is transferred to 10 kg of air which is initially at 100 kPa and 300 K until its temperature reaches 600 K. Determine the change in internal energy, the change in enthalpy, the heat supplied, and the work done in the following processes:
 - (i) Constant volume process (7)
 - (ii) Constant pressure process (7)

Assume that air is an ideal gas for which the P-V-T relationship is $PV = nRT$,

where n is the number of moles of the gas and R is the ideal gas constant, $R=8.314$ kJ/k mol K. Take $C_p = 29.099$ k J/k mol K, $C_v= 20.785$ kJ/k mol K and molecular weight of air = 29.

23. a) (i) An equimolar liquid mixture of species 1 and 2 is in equilibrium with its vapour (7)
at 400 K. At this temperature, the vapour pressure of the species are $P_1^{\text{sat}} = 180$
k Pa and $P_2^{\text{sat}} = 120$ k Pa. Assuming that Raoult's law is valid. Calculate the
mole fraction of liquid (y_1).
- (ii) Derive Gibbs-Duhem equation for binary solutions. List its applications. (7)

(OR)

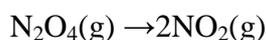
- b) (i) Derive an expression for residual entropy property of a gas. (7)
- (ii) A methanol-water vapour liquid system is at equilibrium at 60°C and 60 k Pa. (7)
The mole fraction of methanol in liquid is 0.5 and in vapour is 0.8. Vapour
pressure of methanol and water at 60°C are 85 k Pa and 20 k Pa respectively.
Assuming vapour phase to be an ideal gas mixture, what is the activity
coefficient of water in the liquid phase and the excess Gibbs free energy (g^E , in
J/mol) of the liquid mixture?

24. a) (i) Explain in detail about positive and negative deviation from ideality with (8)
vapour pressure curves.
- (ii) Liquids A and B form an azeotrope containing 46.1 mole percent A at 101.3 K (6)
Pa. The vapour pressure of A is 84.8 K Pa and that of B is 78.2 K Pa at 345 K.
Calculate the van Laar constants.

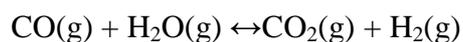
(OR)

- b) (i) Elaborate on minimum-boiling and maximum-boiling azeotropes with P- x - y , T- (10)
 x - y and x - y curves.
- (ii) n - Heptane and toluene form ideal solution. At 373 K, the vapour pressures are (4)
106 K Pa and 74 K Pa respectively. Determine the composition of the liquid
and vapour in equilibrium at 373 K and 101.3 K Pa.

25. a) (i) Calculate the equilibrium constant at 298 K of the reaction. Given that the (7)
standard free energies of formation at 298 K are 97540 J/mol for N_2O_4 and
51310 J/mol for NO_2

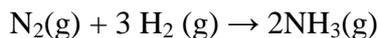


- (ii) The equilibrium constant for the reaction is $K = 1.03 \times 10^5$ at 298.15 K. (7)
Calculate the standard reaction Gibbs energy at this temperature.



(OR)

- b) (i) The standard heat of formation and standard free energy of formation of ammonia at 298 K are -46100J/mol and -16500J/mol respectively. At 500 K assuming that the standard heat of reaction is constant in the temperature range 298 to 500 K. Calculate the equilibrium constant for the reaction (7)



- (ii) Derive an expression relating equilibrium constant, temperature and change in standard free energy. (7)
