

**Fifth Semester B.Tech Degree Examination**

**(2013 Scheme)**

**13.505 THERMODYNAMICS OF BIOPROCESSES(B)**

**SAMPLE QUESTION PAPER**

**Time: 3 Hours**

**Max. Marks: 100**

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*Instructions to candidates: Use of steam table may be permitted  
Answer all questions in Part A. Each question carries 2 marks  
Answer any one full question from each module in Part B. Each  
full question carries 20 marks*

**Part A**

1. Why is inter-stage cooling necessary in multistage compression?
2. What are the major differences between the Otto cycle and the Diesel cycle for IC engines?
3. Compare the Linde process and the Claude process for air liquefaction?
4. Define standard heat of formation?
5. Distinguish between molar volume and partial molar volume?
6. What is the significance of chemical potential?
7. What are the simplifications used in the derivation of Clausius -Clapeyron equation?
8. What is the role of a tie line in determining the amount of liquid and vapour at equilibrium?
9. How would the equilibrium yield of ammonia be affected if argon is present in the synthesis gas fed to the ammonia converter?
10. How is the extent of reaction related to the mole fraction of the species in the reaction mixture?

**Part B**

**Module I**

11. Steam generated in a power plant at a pressure of 8600 kPa and a temperature of 500 °C ( $H=3391.6$  kJ/kg and  $S=6.6858$  kJ/kg) is fed to a turbine. Exhaust from the turbine enters a condenser at 10 kPa, where it is condensed to saturated liquid, which is then pumped to the boiler.
  - a) Determine the thermal efficiency of the Rankine cycle operating at these conditions?

- b) Determine the thermal efficiency of a practical cycle operating at these conditions if the turbine efficiency and pump efficiency are both 75%
- c) If the rating of the power cycle of part (b) is 80000kW, what is the steam rate and what are the heat transfer rates in the boiler? **(7+8+5)**

**OR**

12. a) Show that in two stage reciprocating compressor, the minimum total work results when the pressure ratio in each stage are equal and are given by the square root of the overall pressure ratio.
- b) Carbon dioxide AT 1 bar and 300K is to be compressed to a pressure of 10 bar in a single stage compressor at a rate of 100 m<sup>3</sup>/h. Assuming that CO<sub>2</sub> behaves as an ideal gas, calculate the temperature of the gas after compression and the work required. Assume  $\gamma=1.3$ . **(10+10)**

**Module II**

13. a) Explain on any two methods of determination of partial molar properties. **(8)**
- b) The volume of aqueous solution of NaCl at 298 K was measured for a series of molalities and it was found that the volume varies with the molality according to the following expression.
- $$V=1.003 \times 10^{-3} + 0.1662 \times 10^{-4} m + 0.1777 \times 10^{-5} m^{1.5} + 0.12 \times 10^{-6} m^2$$
- Where m is the molality and V is in m<sup>3</sup>. Calculate the partial molar volumes of the components at m = 0.1 mol/kg. **(12)**

**OR**

14. a) What are activity coefficients? Explain the effect of Temperature on activity coefficients. **(3+3)**
- b) The fugacity of component 1 in a binary mixture of component 1 and 2 at 298 K and 20 bar is given by  $\bar{f}_1 = 50x_1 - 80x_1^2 + 40x_1^3$  where  $\bar{f}_1$  is in bar and  $x_1$  is the mole fraction of component 1. Determine
- The fugacity  $\bar{f}_1$  of the pure component 1
  - The fugacity coefficient  $\Phi_1$
  - The Henry's law constant  $K_1$
  - The activity coefficient  $\gamma_1$  **(4+3+4+3)**

### Module III

15. a) Explain on the vapour-liquid equilibria in ideal solutions.

b) Deduce the Clapeyron equation using the criterion of equilibrium (10+10)

OR

16. a) What are azeotropes? How does pressure and temperature affect the azeotropic composition? (3+4)

b) The vapour pressures of acetone(1) and acetonitrile(2) can be evaluated by Antoine equations as given below.

$$\ln P_1^s = 14.5463 - \frac{2940.46}{T - 35.93}$$

$$\ln P_2^s = 14.2724 - \frac{2945.47}{T - 49.15}$$

The Temperature and Pressure data are given in K and kPa respectively. Assuming the solution formed is ideal calculate

i)  $x_1$  and  $y_1$  at 327 K and 65kPa and

ii) T and  $y_1$  at 65kPa and  $x_1=0.4$  (6+7)

### Module IV

17. a) Derive the equation for the standard free energy change in terms of equilibrium constant. (10)

b) The equilibrium constant of the reaction  $SO_3 \rightarrow SO_2 + \frac{1}{2}O_2$  at 800K is 0.319 and at 900K is 0.153. Determine the mean standard enthalpy change of reaction in the region 800 to 900K.

Given: The molar heat capacity data in ideal gas state as

Species	a	b x 10 <sup>2</sup>	c x 10 <sup>5</sup>	d x 10 <sup>9</sup>
SO <sub>2</sub>	6.157	1.384	-0.9103	2.057
SO <sub>3</sub>	3.918	3.483	-2.675	7.744
O <sub>2</sub>	6.732	0.1505	-0.01791	---

(10)

**OR**

18. a) Given that for the reaction  $SO_2 + \frac{1}{2}O_2 \rightarrow SO_3$   $K=74$  at 749 K. Initially the number of moles of  $SO_2$  is 10,  $O_2$  is 8 and  $SO_3$  are zero. At 749 K and 1 atm calculate the number of moles of  $SO_2$ ,  $O_2$  and  $SO_3$  at equilibrium.

b) If instead the reaction considered is  $2SO_2 + O_2 \rightarrow 2SO_3$ , At 749 K and 1 atm calculate the moles of each species at equilibrium, starting with the same number of moles as above. Assume ideal gas phase reaction.

**(12+8)**