Question Paper

Exam Date & Time: 18-Apr-2018 (09:30 AM - 12:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

INTERNATIONAL CENTRE FOR APPLIED SCIENCES
FOURTH SEMESTER B.S (ENGG)
END - SEMESTER THEORY EXAMINATIONS APRIL - 2018
DATE : 18 APRIL 2018
TIME : 9:30AM TO 12:30PM

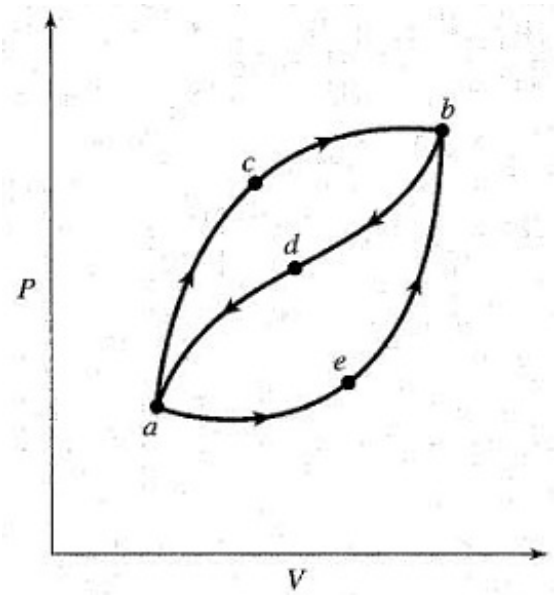
Thermodynamics For Bioprocessing [BT 241]

Marks: 100 **Duration: 180 mins.**

Answer 5 out of 8 questions.

1) A) (i)Distinguish between intensive and extensive properties with suitable example. (3) (12)
(ii) What is control surface and control volume in an open system? (3)
(iii) What is heat pump and COP of a heat pump? (3)
(iv) State Third law of thermodynamics? (3)

B) When a system is taken from state a to state b in fig. 1 along path acb, 100 J of heat flows into the system and the system does 40 J of work. How much heat flows into the system along path aeb if the work done by the system is 20 J? The system returns from b to a through bda. If the work done on the system is 30 J, does the system absorb or liberate heat? How much? (8)



2) A) (i)Define the term 'phase equilibrium'. (2) (10)
(ii) Define chemical potential. (2)
(iii) What is partial molar property? (2)
(iv) What is fugacity coefficient? (2)
(v) What is an adiabatic process? Write the expression for work done during reversible adiabatic process (2)

B) It is required to freeze 1 kg water at 273 K by means of a refrigeration machine (heat pump) which operates in the surrounding at 300 K. The latent heat of fusion of ice at 273 K is 334.11 kJ/kg. Determine the maximum amount of work required and the heat given up to the surrounding (2+3) (5)

C) A steam power plant produces 50 MW of net work while burning fuel to produce 150 MW of heat energy at the high temperature. Determine the cycle thermal efficiency and the heat rejected by the cycle to the surroundings. (5)

3) A) What are limitations of First law of thermodynamics? Enlist the statements of the second law of thermodynamics. (8)

B) Heat is transferred to 10 kg of air which 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
(ii) Constant pressure process
Assume that air is ideal gas for which the P-V-T relationship. Take C_p = 29.099 kJ/kmol K, C_v = 20.785 kJ/kmol K and molecular weight of air =29. (6+6) (12)

4) A) One kmol CO_2 occupies a volume of 0.381 m^3 at 313 K. Compare the pressures given by
(i) Ideal gas equation (4)
(ii) Vander Waals equation (6)
Data: a = 0.365 N m^4/mol^2; b = 4.28 Ã— 10^{-5} m^3/gmol (10)

B) A 40 kg steel casting (C_P = 0.5 kJ kg^{-1} K^{-1}) at a temperature of 450Â°C is quenched in 150 kg of oil (C_P = 2.5 kJ kg^{-1} K^{-1}) at 25Â°C. If there are no heat losses, what is the change in entropy of (i) the casting, (ii) the oil, and (10)

(iii) both considered together?

5) Determine the increase in entropy of solid magnesium when the temperature is increased from 300 K to 800 K. The heat capacity is given by the following relation (7)

A)

$$C_p = 26.04 + 5.586 \times 10^{-3}T, \frac{J}{mol\ K}$$

B) Calculate the vapour pressure of water at 363 K, if the vapour pressure at 373 K is 101.3 kPa. The mean heat of vapourization in that temperature range is 2275 kJ/kg. (7)

C) For a homogeneous phase, prove that (6)

$$dS = C_p \frac{dT}{T} - \beta V dP$$

6) A 30 percent by mole methanol-water solution is to be prepared. How many cubic metres of pure methanol (molar volume, 40.747 x 10^{-6} m^3/mol) and pure water (molar volume, 18.068 x 10^{-6} m^3/mol) are to be mixed to prepare 2 m^3 of the desired solution? The partial molar volumes of methanol and water in a 30 percent solution are 38.632 x 10^{-6} m^3/mol and 17.765 x 10^{-6} m^3/mol, respectively (10)

A)

B) Derive the Gibbs-Duhem equation from fundamentals. (10)

7) For a system in which the following reaction occurs (10)

A)

$$CH_4 + H_2O \rightarrow CO + 3H_2$$

Assume there are present initially 2 mol CH_4, 1 mol H_2O, 1 mol CO and 4 mol H_2 .Determine expressions for the mole fractions y_i as functions of ?

B) Derive an expression for effect of temperature on equilibrium constant for constant and variable enthalpy (10)

8) Explain the dialysis process. Discuss the thermodynamic equilibrium with change in entropy and Gibbs free energy (10)

A)

B) In glycolysis, the enzyme Phosphofructokinase I catalyses the following reaction (10)

$$Fructose-6-phospahe + ATP \rightarrow Fructose1,6-bisphosphate + ADP$$

Given the data below, calculate the equilibrium constant for this reaction

$$ATP \rightarrow ADP + P_i \quad \Delta G^0 = -30.5\ kJ/mol$$

$$Fructose-6-phosphate \rightarrow Fructose1,6biphosphate + P_i \quad \Delta G^0 = 16.0\ kJ/mol$$

-----End-----