Question Paper

Exam Date & Time: 04-May-2019 (02:00 PM - 05:00 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

INTERNATIONAL CENTRE FOR APPLIED SCIENES
IV SEMESTER B.Sc.(Applied Sciences) IN ENGINEERING END SEMESTER THEORY EXAMINATION-APRIL/MAY 2019
BIOLOGICAL THERMODYNAMICS [IBT 245 - S2]

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

Answer 5 out of 8 questions.

1) (14)

A) One mole of an ideal gas, initially at 30^0C and 1 bar, is changed to 130^0C and 10 bar by three different mechanically reversible processes:
a) The gas is heated at constant volume until its temperature is 130^0C; then it is compressed isothermally until its pressure is 10 bar.
b) The gas is first heated at constant pressure until its temperature is 130^0C; then it is compressed isothermally to 10 bar.
c) The gas is first compressed isothermally to 10 bar; then it is heated at constant pressure at 130^0C.
Calculate Q, W, ΔU, and ΔH in each case. Take C_P = (5/2) R and C_V = (3/2)

B) An incompressible liquid flows steadily through a conduit of circular cross-section and increasing diameter. At location 1, the diameter is 2.5 cm and the velocity is 2 m/s; at location 2, the diameter is 5 cm. (6)
a) What is the velocity at location 2?
b) What is the kinetic energy change (J/kg) of the fluid between locations 1 and 2?

2) Using Carnot engine cycle, prove that entropy is a state function. (8)

A)

B) With respect to 1 kg of liquid water: (12)
a) Initially at 0^0C, it is heated to 100^0C by contact with a heat reservoir at 100^0C. What is the entropy change of the water? Of the heat reservoir? What is ΔS_{total}?
b) Initially at 0^0C, it is first heated to 50^0C by contact with a heat reservoir at 50^0C and then to 100^0C by contact with a reservoir at 100^0C. What is ΔS_{total}?
c) Explain how the water might be heated from 0^0C to 100^0C so that ΔS_{total} = 0.

3) Derive Clapeyron and Clausius/ Clapeyron equation for the single component two phase system (10)

A)

B) Derive equation relating molar and partial molar properties and (10)

Gibb's/Duhem equation

4) A) A stream of nitrogen flowing at the rate of 4 kg/s and a stream of oxygen flowing at the rate of 1.5 kg/s mix adiabatically in a steady-flow process. If the gases are assumed ideal, what is the rate of entropy increase as a result of the process? (10)

B) Prove In K = $-\Delta G^{\circ}/RT$ (10)

5) The following reaction is carried out at 1 atmosphere (20)
$SO_2(g) + 1/2O_2(g) \rightarrow SO_3(g)$
The reaction is carried out at a temperature of 855 K, using 20% excess air. Calculate K. At 25°C ΔH° = -98,890 J/mol and ΔG° = -70,866 J/mol
Calculate equilibrium composition. Assume ideal gas and the process is at constant ΔH.

6) A) A system formed initially of 2 mol of CO_2, 5 mol H_2, and 1 mol CO undergoes the reactions: (8)
$CO_2(g) + 3H_2(g) \rightarrow CH_3OH(g) + H_2O(g)$
$CO_2(g) + H_2(g) \rightarrow CO(g) + H_2O(g)$
Develop expressions for the mole fractions of each of the reacting and product species as functions of the reacting coordinates for the two reactions

B) Derive $\ln K/K^{|} = -\Delta H/R\left(\frac{1}{T} - \frac{1}{T^{|}}\right)$ from fundamental equation . (12)

7) A) Acetic acid is esterified in the liquid phase with ethanol at 100°C and atmospheric pressure to produce ethyl acetate and water according to the reaction: (10)
$CH_3COOH(/) + C_2H_5OH(/) \rightarrow CH_3COOC_2H_5(/) + H_2O(l)$
If initially there is one mole each of acetic acid and ethanol, estimate the mole fraction of ethyl acetate in the reacting mixture at equilibrium.
$\Delta H^0 = -3{,}640\ J \text{ and } \Delta G^0 = -4{,}650\ J \text{ at } 298\ K$

B) With proper explanation and equations explain Chemical potential of species i in a mixture of ideal gases. Express chemical potential of species i in an ideal solution mixture using Lewis/Randall rule. If the solution is real, how to express chemical potential of species i in a mixture? (10)

8) A) The sublimation pressure of solid CO_2 is 133 Pa at -134.3°C and at 2660 Pa at -114.4°C Calculate the enthalpy of sublimation. (8)

B) How cell modifies energetically unfavorable reaction to a favorable reaction in glycolysis pathway (6)

C) Why Gibb's free energy calculation is very important in Biological thermodynamics and how it is derived? (6)

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