Code No: R09222304 | R09 | SET-1

B.Tech II Year - II Semester Examinations, April-May, 2012
THERMODYNAMICS FOR BIOTECHNOLOGISTS
(BIOTECHNOLOGY)

Time: 3 hours **Max. Marks: 75**

Answer any five questions
All questions carry equal marks

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1.a) Is it possible to prove the laws of thermodynamics? Discuss in brief.
b) One mole of an ideal gas at 1.0MPa and 310 K is heated at constant pressure till the volume is doubled and then it is allowed to expand at constant temperature till the volume is doubled again. Calculate the work done by the gas. [5+10]

2.a) What is Carnot principle?
b) A cyclic heat engine operates between a source temperature of 750^0C and a sink temperature of 28^0C. What is the least rate of heat rejection per kW net output of the engine? [5+10]

3.a) Name and explain the two different approaches in the study of thermodynamics.
b) State whether supercooled liquid water, that is water at a temperature below 0^0C, is in a state of equilibrium. Classify the equilibrium state. [7+8]

4. Estimate the fugacity of the Cyclopentane at 110^0C and 275 bar. At 110^0C the vapor pressure of cyclopentane is 5.267 bar. [15]

5. If one kmol of methane is stored in a 0.3 m^3 tank at 300K, estimate the pressure of the gas using Redlich - Kwong equation of state. The critical constants of methane are $P_c = 4.6 \times 10^6$ Pa and $T_c = 190.6$ K. [15]

6. Show that the equilibrium state of a closed system is that state for which the total Gibbs energy is a minimum with respect to all possible changes at the given T, P values? [15]

7. For ideal gas mixtures show that $S^{ig} = \sum_i y_i S_i^{ig} - R\sum_i y_i \ln y_i$. [15]

8. For a system in which the following reaction occurs

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

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 mol fractions y_i as functions of reaction co-ordinate? [15]

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Code No: R09222304 | R09 | SET-2

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Time: 3 hours **Max. Marks: 75**

Answer any five questions
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1. An astronaut weighs 730 N in Houston, Texas, where the local acceleration of gravity is g = 9.792 m s^{-2}. What are the astronaut's mass and weight on the moon, where g = 1.67 m^{-2}? [15]

2. An ideal gas is heated at constant volume until its temperature is doubled, then it is expanded isothermally till it reached the original pressure. Finally, the gas is cooled at constant pressure, till it is restored to original state. Determine the network done per mole of the gas. [15]

3.a) What do you mean by chemical equilibrium process?
b) Write the "Phase Rule" and its significance in finding the degrees of freedom. [7+8]

4. Develop a general equation for calculation of lnΦi, values from compressibility-factor data. [15]

5. Using Maxwell relations show that $C_P - C_V = \frac{TV\beta^2}{K}$ where β is volume expansivity and K is isothermal compressibility. [15]

6. What is Dew point and Bubble point and explain the P,x,y and T,x,y diagrams in detail? [15]

7. At constant temperature and pressure for a solution prove that $\sum_i x_i d\bar{M}_i = 0$. [15]

8. Consider a vessel initially contains only no moles of water vapor, if the decomposition occurs according to the reaction

$H_2O \rightarrow H_2 + 1/2O_2$

Find expressions which relate the number of moles and the mole fraction of each chemical species to the reaction co-ordinate? [15]

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Code No: R09222304 | R09 | SET-3

B.Tech II Year - II Semester Examinations, April-May, 2012
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(BIOTECHNOLOGY)

Time: 3 hours **Max. Marks: 75**

Answer any five questions
All questions carry equal marks

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1. Write short notes on
   a) Temperature scales
   b) Pressure
   c) Work
   d) Energy. [15]

2.a) Explain in detail the carnot cycle of the heat engine and applicability of second law of thermodynamics.
b) Write briefly about the limitations and real process of second law of thermodynamics. [7+8]

3.a) Give an example of a fundamental relation.
b) What is an equation of state? How many equations of state are there for a single component of simple compressible substance? [5+10]

4.a) Discuss the importance of fugacity in thermodynamics.
b) Discuss fugacity and fugacity coefficient for pure species. [7+8]

5.a) Estimate the rise in temperature if liquid water at 25^0C is compressed isentropically from 0.1MPa to 10 MPa. For liquid water
C_p = 4.2 kJ/kgK
$\beta = 2.07 \times 10^{-4}$ K^{-1}
Specific volume of liquid water = 0.001003 m^3/ kg
b) Show that $C_p - C_v = R$ [9+6]

6.a) A binary system in equilibrium is represented by the equation $\frac{\Delta G}{RT} = x_1 \ln x_1 + x_2 + \frac{G^E}{RT}$. Show that the solubility of the system requires that $\frac{d^2(G^E / RT)}{dx_1^2} > -\frac{1}{x_1 x_2}$ (at constant T,P).
b) The excess Gibbs energy function for a binary system is represented by $\frac{G^E}{RT} = x_1 \ln \gamma_1 + x_2 \ln \gamma_2$. Show that the condition for stability is $\frac{d \ln \gamma_1}{dx_1} > -\frac{1}{x_1}$ (at constant T,P). [7+8]

7. For a pure species in vapour liquid equilibrium, prove that

a) $f_i^l = f_i^v = f_i^{sat} = \varphi_i^{sat} p_i^{sat}$

b) $f_i = \varphi_i^{sat} p_i^{sat} \exp \frac{V_i^l}{RT}\left(P - P_i^{sat}\right)$. [7+8]

8. Consider a system in which the following reaction occur

$CH_4 + H_2O \rightarrow CO + 3H_2$ 1

$CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$ 2

Where the numbers 1 and 2 indicates the values of j, the reaction index. If there are present initially 2 mol of CH_4 and 3 mole of H_2O. Determine Expressions for mole fractions of all the components y_i as functions of reaction co-ordinates? [15]

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1.a) What do you understand by macroscopic and microscopic view points?
b) How does the subject of thermodynamics differ from the concept of heat transfer? [7+8]

2.a) What are the limitations of first law of thermodynamics?
b) Discuss about general statements of second law of thermodynamics.
c) It is required to freeze 1 kg of water at 273 K by means of refrigeration machine with the surroundings at 300 K. The latent heat of fusion at 273 K is 335 kJ/kg. Determine
i) the minimum amount of work required.
ii) the heat given up to the surroundings. [3+4+8]

3.a) What are limitations of virial equation?
b) What is general cubic equation of state?
c) Define acentric factor.
d) Calculate the mass of ethane contained in a $0.5m^3$ cylinder at 65^0C and 100 bar using pitzer correlation for the second virial coefficient. T_c = 305.4 K P_c = 48.8 bar and ω = 0.098. [3+4+4+4]

4. Develop a general equation for calculation of $\ln\Phi i$, values from compressibility-factor data. [15]

5. A stream of air at atmospheric pressure is cooled continuously from 38^0C to 15^0C. The volumetric flow is $0.5m^3/s$ at 25^0C and 101.33 kPa. The temperature of the ambient air to which the heat is discarded is 38^0C. What is the minimum power requirement of a mechanical refrigeration system to accomplish the necessary cooling? [15]

6. Discuss the equilibrium and stability criteria in a closed system. [15]

7. Show that the fugacity of species i in an ideal gas mixture is equal to its partial pressure? [15]

8. What is reaction co-ordinate and explain the steps involved in finding out the mole fractions of components in the multi reaction stoic hiometry? [15]

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