**R07** 

# Set No. 2

## II B.Tech I Semester Examinations, May 2011 THERMODYNAMICS FOR BIOTECHNOLOGISTS **Bio-Technology**

Time: 3 hours

Code No: 07A32302

Max Marks: 80

[16]

## Answer any FIVE Questions All Questions carry equal marks \*\*\*\*

- 1. Show that multiple phases at constant T and P are in equilibrium when fugacity of each species is the same in all phases i.e.,  $\hat{f}_i^{\alpha} = \hat{f}_i^{\beta} = - - - - = \hat{f}_i^{\eta}$  (i=1,2,-,N)
- 2. With a neat sketch explain the working principle of Batch reactor. [16]
- 3. Anaerobic digestion of volatile acids by methane bacteria is represented by the equation

 $CH_3COOH + NH_3 \rightarrow biomass + CO_2 + H_2O + CH_4$  The composition of the methane bacteria is approximated by the empirical formula  $CH_{1,4}O_{0,4}N_{0,20}$ . For each kg of acetic acid consumed 0.67 kg CO2 is evolved. How does the yield of methane under these conditions compare with maximum possible yield?

- 4. Citric acid is manufactured using submerged culture of aspergillus niger in a batch reactor operated at 30 °C. Over a period of two days, 2500 kg glucose and 860 kg oxygen are consumed to produced 1500 kg citric acid, 500 kg biomass and other products.  $NH_3$  is used as nitrogen source. Power input to the system by mechanical agitation of the broth is about 15 kW. About 100 kg water is evaporated over the culture period. Estimate the cooling requirement. Heat of reaction at 30 °C is -460 kJ/gmol O<sub>2</sub> consumed.  $\Delta H_R$ , water at 30 °C = 2430 kJ/kg. [16]
- 5. A System has equation of state PV=ZRT. Show that.  $\left(\frac{\partial H}{\partial P}\right)_T = -\frac{RT^2}{P} \left(\frac{\partial Z}{\partial T}\right)_P$ Given  $\left(\frac{\partial H}{\partial P}\right)_T = V - T \left(\frac{\partial V}{\partial T}\right)_P$ [16]
- 6. (a) what are the criteria for chemical equilibrium?
  - (b) What is the effect of temperature on the equilibrium constant? [8+8]
- 7. The following heat engine produce power of 95000KW.Determine in each case the rates at which the heat is absorbed from the hot reservoir and discarded to the cold reservoir.
  - (a) A carnot engine operates between heat reservoirs at 7500k and 3000k
  - (b) A practical engine operates between the same heat reservoirs but with a thermal efficiency of 0.35. [8+8]
- 8. Show that when Lewis Randall rule is valid for one species in a binary solution, Henry's law is valid for the other species. [16]

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Set No. 4

# II B.Tech I Semester Examinations, May 2011 THERMODYNAMICS FOR BIOTECHNOLOGISTS **Bio-Technology**

Time: 3 hours

Code No: 07A32302

Max Marks: 80

[16]

## Answer any FIVE Questions All Questions carry equal marks \*\*\*\*

- (a) what are the criteria for chemical equilibrium? 1.
  - (b) What is the effect of temperature on the equilibrium constant? |8+8|
- 2. A System has equation of state PV=ZRT. Show that.  $\left(\frac{\partial H}{\partial P}\right)_T = -\frac{RT^2}{P} \left(\frac{\partial Z}{\partial T}\right)_P$ Given  $\left(\frac{\partial H}{\partial P}\right)_T = V - T \left(\frac{\partial V}{\partial T}\right)_P$
- 3. Anaerobic digestion of volatile acids by methane bacteria is represented by the equation  $CH_3COOH + NH_3 \rightarrow biomass + CO_2 + H_2O + CH_4$  The composition of the methane bacteria is approximated by the empirical formula  $CH_{1,4}O_{0,4}N_{0,20}$ . For each kg of acetic acid consumed 0.67 kg CO2 is evolved. How does the yield of methane under these conditions compare with maximum possible yield? Ys Yxs (Mass Yield) Cmax/w Carbon Yield [16] Acetic Acid 4.0 0.80.95
- 4. Show that when Lewis Randall rule is valid for one species in a binary solution, Henry's law is valid for the other species. 16
- 5. Show that multiple phases at constant T and P are in equilibrium when fugacity of each species is the same in all phases i.e.,  $\hat{f}_i^{\alpha} = \hat{f}_i^{\beta} = \cdots = \hat{f}_i^{\eta}$  (i =1,2,-,N) [16]
- 6. Citric acid is manufactured using submerged culture of aspergillus niger in a batch reactor operated at 30 °C. Over a period of two days, 2500 kg glucose and 860 kg oxygen are consumed to produced 1500 kg citric acid, 500 kg biomass and other products.  $NH_3$  is used as nitrogen source. Power input to the system by mechanical agitation of the broth is about 15 kW. About 100 kg water is evaporated over the culture period. Estimate the cooling requirement. Heat of reaction at 30  $^{\circ}\mathrm{C}$  is -460 kJ/gmol O<sub>2</sub> consumed.  $\Delta H_R$ , water at 30 °C = 2430 kJ/kg. [16]
- 7. With a neat sketch explain the working principle of Batch reactor. [16]
- 8. The following heat engine produce power of 95000KW.Determine in each case the rates at which the heat is absorbed from the hot reservoir and discarded to the cold reservoir.
  - (a) A carnot engine operates between heat reservoirs at 7500k and 3000k
  - (b) A practical engine operates between the same heat reservoirs but with a thermal efficiency of 0.35. [8+8]

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#### Set No. 1

## II B.Tech I Semester Examinations, May 2011 THERMODYNAMICS FOR BIOTECHNOLOGISTS **Bio-Technology**

Time: 3 hours

Code No: 07A32302

Max Marks: 80

## Answer any FIVE Questions All Questions carry equal marks \*\*\*\*

- 1. (a) what are the criteria for chemical equilibrium?
  - (b) What is the effect of temperature on the equilibrium constant? |8+8|
- 2. With a neat sketch explain the working principle of Batch reactor [16]
- 3. Anaerobic digestion of volatile acids by methane bacteria is represented by the equation

 $CH_3COOH + NH_3 \rightarrow biomass + CO_2 + H_2O$  $+ CH_4$ The composition of the methane bacteria is approximated by the empirical formula  $CH_{1,4}O_{0,4}N_{0,20}$ . For each kg of acetic acid consumed 0.67 kg CO2 is evolved. How does the yield of methane under these conditions compare with maximum possible yield?

Yxs (Mass Yield) Qmax/w Carbon Yield Ys [16]Acetic Acid 4.0 0.8 0.95

- 4. The following heat engine produce power of 95000KW.Determine in each case the rates at which the heat is absorbed from the hot reservoir and discarded to the cold reservoir.
  - (a) A carnot engine operates between heat reservoirs at 750ok and 300ok
  - (b) A practical engine operates between the same heat reservoirs but with a thermal efficiency of 0.35. [8+8]
- 5. Citric acid is manufactured using submerged culture of aspergillus niger in a batch reactor operated at 30 °C. Over a period of two days, 2500 kg glucose and 860 kg oxygen are consumed to produced 1500 kg citric acid, 500 kg biomass and other products.  $NH_3$  is used as nitrogen source. Power input to the system by mechanical agitation of the broth is about 15 kW. About 100 kg water is evaporated over the culture period. Estimate the cooling requirement. Heat of reaction at 30  $^{\circ}\mathrm{C}$  is -460 kJ/gmol O<sub>2</sub> consumed.  $\Delta H_R$ , water at 30 °C = 2430 kJ/kg. [16]

6. A System has equation of state PV=ZRT.  
Show that. 
$$\left(\frac{\partial H}{\partial P}\right)_T = -\frac{RT^2}{P} \left(\frac{\partial Z}{\partial T}\right)_P$$
  
Given  $\left(\frac{\partial H}{\partial P}\right)_T = V - T \left(\frac{\partial V}{\partial T}\right)_P$ 
[16]

7. Show that multiple phases at constant T and P are in equilibrium when fugacity of each species is the same in all phases i.e.,  $\hat{f}_i^{\alpha} = \hat{f}_i^{\beta} = - - - - = \hat{f}_i^{\eta}$  (i =1,2,-,N) [16]

8. Show that when Lewis Randall rule is valid for one species in a binary solution, Henry's law is valid for the other species. [16]

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#### Set No. 3

## II B.Tech I Semester Examinations, May 2011 THERMODYNAMICS FOR BIOTECHNOLOGISTS **Bio-Technology**

Time: 3 hours

Code No: 07A32302

Max Marks: 80

## Answer any FIVE Questions All Questions carry equal marks \*\*\*\*

- 1. With a neat sketch explain the working principle of Batch reactor. [16]
- 2. The following heat engine produce power of 95000KW. Determine in each case the rates at which the heat is absorbed from the hot reservoir and discarded to the cold reservoir.
  - (a) A carnot engine operates between heat reservoirs at 750ok and 300ok
  - (b) A practical engine operates between the same heat reservoirs but with a thermal efficiency of 0.35. [8+8]
- 3. Show that when Lewis Randall rule is valid for one species in a binary solution, Henry's law is valid for the other species. 16
- 4. A System has equation of state PV=ZRT. Show that.  $\left(\frac{\partial H}{\partial P}\right)_T = -\frac{RT^2}{P} \left(\frac{\partial Z}{\partial T}\right)_P$ Given  $\left(\frac{\partial H}{\partial P}\right)_T = V - T \left(\frac{\partial V}{\partial T}\right)_P$ [16]
- 5. (a) what are the criteria for chemical equilibrium? (b) What is the effect of temperature on the equilibrium constant? |8+8|
- 6. Citric acid is manufactured using submerged culture of aspergillus niger in a batch reactor operated at 30 °C. Over a period of two days, 2500 kg glucose and 860 kg oxygen are consumed to produced 1500 kg citric acid, 500 kg biomass and other products.  $NH_3$  is used as nitrogen source. Power input to the system by mechanical agitation of the broth is about 15 kW. About 100 kg water is evaporated over the culture period. Estimate the cooling requirement. Heat of reaction at 30 °C is -460 kJ/gmol O<sub>2</sub> consumed.  $\Delta H_R$ , water at 30 °C = 2430 kJ/kg. [16]
- 7. Anaerobic digestion of volatile acids by methane bacteria is represented by the equation  $CH_3COOH + NH_3 \rightarrow biomass + CO_2 + H_2O + CH_4$  The composition of the methane bacteria is approximated by the empirical formula  $CH_{1.4}O_{0.4}N_{0.20}$ . For each kg of acetic acid consumed 0.67 kg CO2 is evolved. How does the yield of methane under these conditions compare with maximum possible yield?

$$\begin{array}{ccc} Ys & Yxs (Mass Yield) & Cmax/w Carbon Yield \\ Acetic Acid & 4.0 & 0.8 & 0.95 \end{array}$$
[16]

8. Show that multiple phases at constant T and P are in equilibrium when fugacity of each species is the same in all phases i.e.,  $\hat{f}_i^{\alpha} = \hat{f}_i^{\beta} = - - - - = \hat{f}_i^{\eta}$  ( i =1,2,-,N) [16]

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