| Reg.No.: | | | | | | | | | | | | |
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VIVEKANANDHA COLLEGE OF ENGINEERING FOR WOMEN
[AUTONOMOUS INSTITUTION AFFILIATED TO ANNA UNIVERSITY, CHENNAI]
Elayampalayam – 637 205, Tiruchengode, Namakkal Dt., Tamil Nadu.

**Question Paper Code: 90032**

B.E. / B.Tech. DEGREE END-SEMESTER EXAMINATIONS – JAN. 2025
Fourth Semester
Biotechnology
U19BT408 – THERMODYNAMICS FOR BIOTECHNOLOGISTS
(Regulation 2019)

Time: Three Hours Maximum: 100 Marks

Answer ALL the questions

| Knowledge Levels (KL) | K1 – Remembering | K3 – Applying | K5 - Evaluating |
|---|---|---|---|
| | K2 – Understanding | K4 – Analyzing | K6 - Creating |

PART – A

(10 x 2 = 20 Marks)

| Q.No. | Questions | Marks | KL | CO |
|---|---|---|---|---|
| 1. | Define Internal Energy. | 2 | K1 | CO1 |
| 2. | Write the application of second law of thermodynamics. | 2 | K2 | CO1 |
| 3. | Define partial molar volume. | 2 | K1 | CO2 |
| 4. | Differentiate path function and state function. | 2 | K2 | CO2 |
| 5. | State heat capacities of fluid. | 2 | K2 | CO3 |
| 6. | Define standard heat of combustion. | 2 | K2 | CO3 |
| 7 | Write the application of Carnot cycle. | 2 | K2 | CO4 |
| 8. | Calculate Vapour Pressure of water at 363K, if the vapour pressure at 373 K is 101.3Kpa. The mean heat of vaporization in this temperature range is 2275kj/kg. | 2 | K3 | CO4 |
| 9. | Differentiate aerobic and anerobic digestion. | 2 | K1 | CO5 |
| 10. | Compare oxidation and reduction reaction in bioenergetics. | 2 | K2 | CO5 |

## PART – B

(5 x 13 = 65 Marks)

| Q.No. | | | Questions | Marks | KL | CO |
|---|---|---|---|---|---|---|
| 11. | a) | i. | A spherical balloon of diameter 0.5 m contains a gas at 1 bar and 300K. The gas is heated and the balloon is allowed to expand. The pressure inside the balloon is found to vary linearly with the diameter. What would be the work done by the gas when the pressure inside reaches 5 bar? | 6 | K4 | CO1 |
| | | ii. | Prove that internal Energy is a state function. | 7 | K1 | CO1 |
| | | | (OR) | | | |
| | b) | | Discuss the first law of thermodynamics for flow process. | 13 | K2 | CO1 |
| 12. | a) | i. | Derive the equations for change in entropy of a fluid in terms of the P-V-T relationship and specific heat data. | 8 | K2 | CO2 |
| | | ii. | Calculate the fugacity of liquid water at 303 Kand 10 bar if the saturation pressure at 303K is 4.241 kPa and the specific volume of liquid water at 303K is 1.004 x $10^{-3}$ $m^3$/kg. | 5 | K4 | CO2 |
| | | | (OR) | | | |
| | b) | | At 300 K and 1 bar the volumetric data for a liquid mixture of benzene and Cyclohexane are represented by V = 109.4 X 10^-6 – 16.8 X 10^-6 – 2.64 X 10^-6 x^2, where x is the mole fraction of benzene and V has the units of m^3/mol. Find expressions for the partial molar volumes of benzene and Cyclohexane. | 13 | K5 | CO2 |
| 13. | a) | | Define heat capacity and discuss in detail about heat effect of industrial reactions. | 13 | K3 | CO3 |
| | | | (OR) | | | |
| | b) | | Calculate the heat of formation of methane gas from the following heat combustion data: | 13 | K4 | CO3 |
| | | i. | $CH_4$ (g) + $2O_2$ --- $CO_2$(g) + $2H_2O$(l); $\Delta H_{298}^{o}$ = - 890.94Kj. | | | |
| | | ii. | C (s) + $O_2$ (g) --- $CO_2$(g); $\Delta H^{o}_{298}$ = -393.78 kj. | | | |
| | | iii. | $H_2$ (g) + ½ $O_2$ (g) --- $H_2O$(l); $\Delta H^{o}_{298}$ = -298.03kJ. | | | |
| 14. | a) | i. | Mercury has a density of 13.69 x $10^3$ kg/$m^3$ in the liquid state and 14.19 x $10^3$ kg/$m^3$ in the solid state, both measured at the melting point of mercury at 10 bars? | 5 | K4 | CO4 |

| | | | | | |
|---|---|---|---|---|---|
| | | ii. | Show that for a gas obeying van der waals equation of state, $C_P - C_V = R/1-2a(V-b)^2/(RTV^3)$ Where a and b are van der waals constants. | 8 | K4 CO4 |
| | | | (OR) | | |
| | b) | | Derive Maxwell equations and explain is their importance in establishing relationships between thermodynamic properties. | 13 | K4 CO4 |
| 15. | a) | | What is NADH and ATP, Explain the function and application in Energy producing process. | 13 | K3 CO5 |
| | | | (OR) | | |
| | b) | | How do you determine the oxygen requirement and heat generation in aerobic growth. | 13 | K5 CO5 |

## PART – C

(1 x 15 = 15 Marks)

| Q. No. | | | Questions | Marks | KL | CO |
|---|---|---|---|---|---|---|
| 16. | a) | | The following values refer to the Wilson parameters for the system acetone (1) – water (2)<br>A12 = 122.531 Jol/mole, A21 = 6051.01J/mol, V1 = $74.05 \times 10^{-6}$ $m^3$/mol. The vapour pressure is given by<br>Ln $P_1$sat = 14.39155- 2795.817/T - 43.198<br>Ln $P_2$ Sat = 16.26205 – 3799.887/T - 46.854<br>Where P is in kPa and T is in K. Calculate the equilibrium pressure and composition of Vapour in equilibrium with a liquid of composition: $x_1$ = 0.43 at 349K. The liquid in equilibrium with a vapour of concentration: $y_1$ = 0.8 at 349 K. | 15 | K5 | CO3 |
| | | | (OR) | | | |
| | b) | i. | Discuss about the different types of thermodynamic diagrams. List their respective fields of application. | 10 | K3 | CO2 |
| | | ii. | What is fundamental differential equation for the energy properties? List the canonical variables for U, H, A and G. | 5 | K3 | CO2 |