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B.TECH. DEGREE EXAMINATIONS: APRIL / MAY 2009

Fourth Semester

BIOTECHNOLOGY

U07BT403 Chemical Thermodynamics and Bio Thermodynamics

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Time: Three Hours

Maximum Marks: 100

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Answer ALL the Questions:-

PART A (20 x 1 = 20 Marks)

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1. $C_P = C_V$ for a fluid

   A. Which is compressible

   B. Whose volume coefficient of expansion is negligible

   C. Which is homogenous

   D. Under normal temperature and pressure

2. The equation of state for a certain gas is given by $P(V-b) = RT$, where b is a positive constant. The Joule-Thomson coefficient of this gas would be

   A. Positive

   B. Negative

   C. Zero

   D. Positive within the inversion points

3. Compressibility factor Z of a gas is

   A. The ratio of fugacity in the given state to fugacity in the standard state

   B. The ratio of actual volume to the volume of the gas if it were ideal

   C. The change in volume with temperature at constant pressure

   D. The difference between actual volume and ideal gas volume

4. The second law of thermodynamics states that

   A. The energy change of a system undergoing any reversible process is zero

   B. It is not possible to transfer heat from a lower temperature to a higher temperature

   C. The total energy of the system and the surroundings remain constant

   D. None of the above

5. For a reversible process occurring at constant temperature and pressure, the decrease in Gibbs free energy measures

   A. The maximum reversible work

   B. The maximum reversible work, other than the electrical work

   C. The maximum reversible work, other than the work of expansion

   D. The heat supplied

6. Fugacity has the same dimensions as that of

   A. Gibbs free energy

   B. Pressure

   C. Temperature

   D. Fugacity is dimensionless

7. Chemical potential is

    A. An extensive property   B. An intensive property

    C. A path property   D. A reference property

8. Which one of the following is incorrect with reference to partial molar properties?

    A. They are always intensive properties

    B. They are always positive

    C. They represent the contribution of individual components to the total solution property

    D. They vary with composition of the solution

9. A solution exhibiting positive deviation from ideality

    A. Always forms a minimum boiling azeotrope

    B. Always forms a maximum boiling azeotrope

    C. Has a total vapor pressure that is less than that predicted by Raoult's law

    D. When formed from its constituents there is absorption of heat

10. In a binary liquid solution of components A and B, if component A exhibits positive deviation from Raoult's law then component B

    A. Exhibits positive deviation from Raoult's law

    B. Exhibits negative deviation from Raoult's law

    C. Obeys Raoult's law

    D. May exhibit either positive or negative deviation from Raoult's law

11. Assume that benzene is insoluble in water. The normal boiling points of benzene and water are 353.3 K and 373.2K, respectively. At a pressure of 1 atm, the boiling point of a mixture of benzene and water is

    A. 353.3 K   B. less than 353.3 K

    C. greater than 353.3 K but less than 373.3 K   D. 373.3 K

12. The number of degrees of freedom for an azeotropic mixture of ethanol and water in vapor-liquid equilibrium is

    A. 3   B. 1   C. 2   D. 0

13. For evaluation of heat effects, all thermochemical equations can be treated as algebraic equations. This is a consequence of

    A. Le Chatlier's principle   B. Third law of thermodynamics

    C. Hess's law   D. Principle of corresponding states

14. The equilibrium constant is independent of

    A. The pressure at equilibrium

    B. The temperature at equilibrium

    C. The number of moles involved in the stoichiometric equation for the reaction

    D. The temperature and pressure at the equilibrium

15. For the reaction $N_2 + 3H_2 \rightarrow 2NH_3$, the increase in pressure results in

    A. Increase of K

    B. Decrease of K

    C. Increase in the concentration of ammonia at equilibrium

    D. Decrease in the concentration of ammonia at equilibrium

16. An exothermic gas-phase reaction proceeds according to the equation $3A + 2B \rightarrow 2R$ the equilibrium conversion for this reaction:

    A. Increases with an increase in temperature

    B. Decreases on dilution with an inert gas

    C. Decreases with an increase in pressure

    D. Is affected by the presence of a catalyst

17. Entropy change of a system is zero in

    A. Reversible process   B. Adiabatic process

    C. Reversible adiabatic process   D. Isothermal process

18. The ordinary vapor compression cycle for refrigeration is less efficient than the Carnot cycle, because in the former

    A. Evaporation process is non-isothermal

    B. A two-phase mixture is to be compressed

    C. Vapor leaving the compressor is superheated

    D. Expansion process results in liquefaction

19. The main feature of an absorption refrigeration unit is

    A. The absence of compression step   B. The absence of expansion step

    C. The absence of condensation step   D. None of the above

20. The Carnot cycle consists of following steps:

    A. Two isothermals and two isentropics   B. Two isobarics and two isothermals

    C. Two isochorics and two isobarics   D. Two isothermals and two isochorics

PART B (5 x 16 = 80 marks)

21. (a) Derive the Maxwell's relations from the thermodynamic properties.

(OR)

21. (b) Derive the residual properties from the virial equation of state.

22. (a) (i) Discuss Gibb's – Duhem equations and its various forms. Give its applications (10)

       (ii) State and explain Lewis Randall rule.   (6)

(OR)

22. (b) (i) Explain in detail about the concept of fugacity.   (10)

       (ii) Explain tangent-intercept method for determination of partial molar properties. (6)

23. (a) The following data were reported got VLE for ethanol – water system at 298 K. Test whether the data are thermodynamically consistent. The vapor pressures of ethanol and water are 7.86 kPa and 3.17 kPa respectively.

x_1	0	0.122	0.163	0.226	0.320	0.437	0.579	0.830	1.0
y_1	0	0.474	0.531	0.562	0.582	0.620	0.685	0.849	1.0
P kPa	3.17	5.57	6.02	6.38	6.74	7.02	7.30	7.78	7.86

(OR)

23. (b) (i) Show that Van-Laar equation is consistent with Duhem's equation.   (8)

(ii) What is meant by tie line? How does the tie line help in determining the amount of liquid and vapor in equilibrium?   (8)

24. (a) (i) Write the effect of temperature on equilibrium constant.   (8)

(ii) The standard heat of formation and standard free energy of formation of ammonia at 298 K are -46,100 J/mol and -16,500 J/mol respectively. Calculate the equilibrium constant for the reaction N_2 (g) + $3H_2$ (g) $2NH_3$ (g) at 500 K assuming that the standard heat of reaction is constant in the temperature range 298 to 500 K.   (8)

(OR)

24. (b) (i) How would you predict the feasibility of a reaction from the value of the standard free energy change?   (8)

(ii) A gas mixture containing 25% CO, 55% H_2 and 20% inert gas is to be used for methanol synthesis. The gases issue from the catalyst chamber in chemical equilibrium with respect to the reaction CO (g) + $2H_2$ (g) CH_3OH (g) at a pressure of 300 bar and temperature of 625 K. Assume that the equilibrium mixture forms an ideal solution and K_f and K_ϕ are 4.9 x 10^{-5} and 0.35 respectively. What is the percent conversion of CO?   (8)

25. (a) (i) Discuss the properties of a refrigerant.   (8)

(ii) Explain with a schematic diagram the working of an absorption refrigeration system.   (8)

(OR)

25. (b) Explain briefly about Rankine and Reheat cycle.

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