KUMARAGURU
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Register Number:……………………..

B.TECH DEGREE EXAMINATIONS: NOV/ DEC 2014

(Regulation 2009)

Fourth Semester

BIOTECHNOLOGY

BTY109: Biochemical Thermodynamics

Time: Three Hours   **Maximum Marks: 100**

Answer ALL Questions:-

PART A (10 x 1 = 10 Marks)

1. For a reversible process, at the end ……. is/are zero for the combined process.

    a) Temperature
    b) Isobaric work done
    c) The net exchange of heat and work
    d) Both temperature and pressure

2. The conversion of heat into work by any heat engine (including Carnot engine) is always less than 100 %. because

    a) For a cyclic process, at the end of every cycle, some amount of the heat must be rejected in order to restore the original properties
    b) The temperature of the source cannot be increased beyond a limit
    c) It is not possible to completely remove heat from the engine
    d) Heat always flows from high temperature to low temperature

3. All the gases behave like ideal gas

    a) At low temperature and high pressure
    b) At high temperature and low pressure
    c) At low temperature and low pressure
    d) At high temperature and high pressure

4. Which of the following equation has the strong theoretical background?

    a) Van der Waals equation
    b) Redlich-Kwong equation
    c) Redlich-Kwong-Soave equation
    d) Virial equation of state

5. Bubble point may be the

    a) Boiling point of a mixture at a given composition
    b) Always equal to boiling point
    c) Always less than boiling point
    d) The temperature at which the first drop of condensate is formed

6. At vapour-liquid equilibrium,
   a) The composition of vapour is equal to the composition of liquid
   b) The composition of vapour is independent of the composition of liquid
   c) The liquid cannot be converted into vapour
   d) There is no net transfer of components between vapour and liquid phases

7. At chemical reaction equilibrium
   a) The Gibbs free energy is minimum and the change in Gibbs free energy is zero
   b) The Gibbs free energy is maximum and the change in Gibbs free energy is zero
   c) The temperature and pressure are maximum
   d) The temperature and pressure are minimum

8. The equilibrium composition of a homogeneous single reaction
   a) Depends on stoichiometric coefficient only
   b) Is independent of inert content
   c) Depends on reaction coordinate only
   d) Depends on both stoichiometric coefficient and inert content

9. The energy in biological system primarily stored and transferred via
   a) ATP
   b) UTP
   c) CTP
   d) GTP

10. During the period of balanced growth,
   a) There is no growth
   b) The growth rate is constant with respect to time
   c) The stationary phase starts
   d) All components of a cell grow at the same rate

PART B (10 x 2 = 20 Marks)

11. Show that the heat transferred is zero during adiabatic process.
12. Differentiate between reversible and irreversible processes.
13. Define residual property and give examples.
14. What do you understand from compressibility factor?
15. Define 'azeotrope' formation in distillation operation.
16. What are 'extract' and 'raffinate' in liquid-liquid equilibrium?
17. Differentiate between 'equilibrium conversion' and 'yield'.
18. Mention the choice of standard state for solids, liquids and gases.
19. What is the reason for differences in microbial metabolism?
20. What do you understand from 'diauxic growth'?

PART C (5 x 14 = 70 Marks)

21. a) Heat is transferred to 1 kg of air which is initially at 100 kPa and 300 K until its temperature reaches 600 K. Determine the change in internal energy, the change in enthalpy, the heat supplied, and the work done in the following processes:

(i) Constant volume process

(ii) Constant pressure process

Assume that air is an ideal gas for which the P-V-T relationship is PV = nRT, where n is the number of mole of the gas and R is the gas constant. R = 8.314 kJ/(kmol K). Take C_p = 29.099 kJ/(kmol K), C_v = 20.785 kJ/(kmol K) and molecular weight of air = 29.

(OR)

b) (i) A rigid and insulated tank of 2 m^3 volume is divided into two equal compartments by a partition. One compartment contains an ideal gas at 400 K and 3 MPa, while the second compartment contains the same gas at 600 K and 1 MPa. The partition is punctured and the gases are allowed to mix. Determine the entropy change of the gas. The isobaric molar heat capacity of the gas is equal to $\frac{5}{2}$R.   (10)

(ii) An inventor claims to have developed an engine that produces 1200kJ of work while receiving 1000kJ of heat from a single heat reservoir. Such an engine would violate both the first and second laws of thermodynamics. Do you agree? Why?   (4)

22. a) One k mol of ammonia is contained in a 0.6 m^3 vessel immersed in a constant temperature bath at 200 °C. Calculate the pressure developed by the gas by each of the following

(i) Ideal gas law.   (2)

(ii) Van der Waals equation   (6)

(ii) Redlich-Kwong equation.   (6)

For ammonia P_C = 11.277 MPa

T_C = 405.6 K

(OR)

b) (i) At 300 K and 1 bar, the volumetric data for a liquid mixture of benzene and cyclohexane are represented by V = 109.4 × 10^{-6} − 16.8 × 10^{-6}x − 2.64 × 10^{-6} x^2, where x is the mole fraction of benzene and V has the units of m^3/mol. Find the   (10)

expressions for the partial molar volumes of benzene and cyclohexane.

(ii) Discuss in brief about the non-ideal behaviour of gases. (4)

23. a) Show that for a stable liquid phase, the fugacity of each component in a binary mixture always increases with increase in concentration at constant temperature and pressure.

(OR)

b) Prove that if Raoult's law is valid for one constituent of a binary solution over the whole concentration range, it must also apply to the other constituent.

24. a) In the synthesis of ammonia, stoichiometric amounts of nitrogen and hydrogen are sent to a reactor where the following reaction occurs

$$N_2 \quad + \quad 3H_2 \quad \rightarrow \quad 2NH_3$$

The equilibrium constant for the reaction at 675 K may be taken equal to 2×10^{-4}.

(i) Determine the percentage of conversion of nitrogen to ammonia at 675 K and 20 bar. (8)

(ii) What would be the conversion at 675 K and 200 bar? (6)

(OR)

b) Derive an expression that relates the standard Gibbs free energy change and the reaction equilibrium constant.

25. a) Explain in detail about the various technological aspects of glucose metabolism.

(OR)

b) Explain the various aspects of the following:

(i) Substrate-limited growth (7)

(ii) Models with growth inhibitors (7)

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