Sub. Code: 6701

-t-RNA synthesis.

(2x5)

ıctose operon.

(2x5)

:hain reaction.

(2x5)

Exam.Code:0908
Sub. Code: 6702

1058

B.E. (Biotechnology) Fourth Semester

BIO-412: Thermodynamics

Time allowed: 3 Hours **Max. Marks: 50**

***NOTE:** Attempt five questions in all, including Question No. I which is compulsory and selecting two questions from each Section.*

x-x-x

Q.1.a) The work done by a closed system in a reversible process is always __________ that done in an irreversible process..

b) A piston cylinder contains air at 600 kPa, 290 K and a volume of $0.01 m^3$. A constant pressure process gives 54 kJ of work output. What is the final volume of air?

c) Define extensive and intensive properties. Give examples

d) Why is the specific heat at constant pressure always greater than that at constant volume?

e) State the third law of thermodynamics.

f) ATP hydrolysis involves the hydrolysis of which bond?

g) Define fugacity? Give its significance.

h) In a constant volume process, internal energy change is equal to its __________

i) State Hess Law.

j) A law which is applicable only to ideal vapors and liquids, that equates the equilibrium partial pressures of a solution component in the coexisting phases, is known as__________ **(1×10)=10**

SECTION-A

Q.2a). A mass of 8 kg gas expands within a flexible container according to the relation $PV^{1.2}$ = constant. The initial pressure is 1000 kPa and the initial volume is $1 m^3$. The final pressure is 5 kPa. If the specific internal energy of the gas decreases by 40 kJ/kg. Calculate the amount of heat transferred.

b). One mole of an ideal gas, initially at 150°C and 8 bar, undergoes the following mechanically reversible changes. It expands isothermally to a pressure such that when it is cooled at constant volume to 50°C its final pressure is 3 bar. Calculate Q, W, ΔU and ΔH for the process. Take $C_p = \frac{7}{2}R$ and $C_v = \frac{5}{2}R$ (3,7)

Q.3a). The food compartment of a refrigerator is maintained at 4°C by removing heat from it at a rate of 360 kJ/min. If the required power input to the refrigerator is 2 kW, determine (a) the coefficient of performance of the refrigerator and (b) the rate of heat rejection to the room that houses the refrigerator.

b). A refrigerating machine using ammonia as the refrigerant is employed for producing 500 kg/hr of ice from water. Ammonia boils at 266 K and condenses at 293 K. The water in the condenser gets heated from 283 K to 288 K. Calculate the theoretical minimum power of the compressor and the rate of circulation of cooling water. The latent heat of fusion of water is 339.1 kJ/kg. **(5+5)**

P.T.O.

Q.4a). **With the help of a diagram explain the Claude process for air liquefaction. Also derive an expression in terms of enthalpies that can be used to calculate the liquid yield.**

b). Briefly discuss the desirable properties of an ideal refrigerant. (7+3)

SECTION-B

Q.5a). Acetic acid is esterified in the liquid phase with ethanol at 100°C and atmospheric pressure to produce ethyl acetate and water according to the reaction

$$CH_3COOH(l) + C_2H_5OH(l) \rightarrow CH_3COOC_2H_5(l) + H_2O(l)$$

If initially there is one mole each of acetic acid and ethanol, estimate the mole fraction of ethyl acetate in the reaction mixture at equilibrium.

Given: ΔH^o_{rxn}= -3640 J and $\Delta G^o_{rxn} = -4650\,J$

b). In the synthesis of ammonia stoichiometric amounts of nitrogen and hydrogen are sent to a reactor. The equilibrium constant for the reaction at 675 K is 2×10^{-4}. Determine the percent conversion of nitrogen to ammonia at 675 K and 20 bar pressure. What would be the conversion if the pressure is increased to 200 bar while the temperature remains constant at 675 K. Assume ideal gas behavior. (5+5)

Q.6a). Briefly explain the thermodynamics of ATP hydrolysis in living cells.

b). Assuming Raoult's law to be valid for 1-Chlorobutane (1) and Chlorobenzene (2) system, for which Antoine equations are

$$\ln P_1^s(kPa) = 13.7965 - \frac{2723.73}{T(K) - 54.89} \qquad \ln P_2^s(kPa) = 13.8635 - \frac{3174.78}{T(K) - 61.45}$$

Calculate (a) x_1 and y_1 at 363 K and 90 kPa (b) P and x_1 at 363 K and y_1=0.4 (3+7)

Q.7. For the methanol synthesis reaction, the equilibrium conversion to methanol is large at 300 K, but decreases rapidly with an increase in temperature. For a feed mixture of carbon monoxide and hydrogen in stoichiometric proportions calculate the equilibrium mole fraction of methanol at 1 bar and 300 K.

$$CO(g) + 2H_2(g) \rightarrow CH_3OH(g)$$

Given that the standard heat of reaction and standard free energy of reaction at 298 K is -90,135 J/mol and -24,791 J/mol respectively. The specific heat (J/mol K) data is given below

$$C_{p_{CO}} = 28.07 + 4.63 \times 10^{-3}T - 0.26 \times 10^{-5}T^{-2}$$
$$C_{p_{H_2}} = 27.01 + 3.51 \times 10^{-3}T + 0.69 \times 10^{-5}T^{-2}$$
$$C_{p_{CH_3OH}} = 18.38 + 101.56 \times 10^{-3}T - 28.68 \times 10^{-6}T^{2}$$

(10)

x-x-x