Reg. No.										

प्रज्ञानं ब्रह्म

Manipal
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INTERNATIONAL CENTRE FOR APPLIED SCIENCES

(Manipal University)

II SEMESTER B.S. DEGREE EXAMINATION – JUNE 2016

SUBJECT: PROCESS & BIOPROCESS CALCULATIONS (BT 121)

(BRANCH: BIO -TECH)

MONDAY, 13TH JUNE, 2016

Time: 3 Hours **Max. Marks: 100**

- ✓ **Answer ANY FIVE FULL Questions.**

1A. In the manufacture of nitric acid, initially ammonia and air are mixed at 0.71 MPa gauge and 923 K. The composition of the mixture on volume basis is as follows, N_2 = 70.5%, O_2 = 18.8%, H_2O = 1.2% and NH_3 = 9.5%. Find the density of gas mixture using ideal gas law in kg/m^3.

1B. A gaseous mixture consists of three components, A, B and C. Analysis of the mixture showed it contains 40 mol% A, 18.75 mass% B, and 20 mol% C. The molecular weight of A and C are 40 and 50 respectively. Find the molecular weight of B and the average molecular weight of the gas mixture.

1C. Sample of Light Diesel Oil (LDO) from a refinery is found to contain 0.75% (by mass) of Sulphur. The density of LDO is 0.85 kg/L at 303.15 K. Convert the impurity into ppm (mg/L).

[6+10+4 Marks]

2A. The molality of an aqueous solution of $MgCl_2$ (MW = 95) is 10. The density of the solution is 1.15 g/mL at 350 K. Determine the following:

a) The weight percent of $MgCl_2$ in the solution
b) The molarity of the solution at 350 K
c) The normality of the solution at 350 K
d) The composition of the solution in mole percent

2B. A gas mixture has the following composition by mole %: Benzene 23.2 %, Methane 15.8 %, Oxygen 12.7 %, Nitrogen 8.7 %, Carbon dioxide 32.7 %, Sulphur dioxide 7.9 %. Find

a) The average molecular mass of the gas mixture
b) The composition of mass
c) The density of the mixture at 975 mm of Hg and 39°C
d) The specific gravity

[12+8 Marks]

3A. The vapour pressure of chloroform is given by the Antoine equation

$\ln P^s = 13.9582 - \frac{2696.79}{T-46.16}$ when the pressure is in kPa and the temperature in K. Determine

a) The boiling point of chloroform at 50 kPa

b) The vapour pressure at 300 K

3B. A solution contains 50 % Benzene, 30% Toluene and 20 % Xylene (by weight) at a temperature of 100°C. The vapours are in contact with the solution. Calculate the total pressure and the molar % composition of the liquid and the vapour. The vapour pressures and the molecular weight are given in table:

Components	**Vapour Pressure (mm of Hg)**	**Molecular weight**
Benzene	1340	78
Toluene	560	92
Xylene	210	106

[5+15 Marks]

4A. Oilseeds containing 49 % oil, 40 % pulp, 3 % mineral salts and the rest moisture are leached with hexane as the solvent. The under flow from the leaching operation contains 25 % hexane, 2.5 % salts, 15 % oil and 7.5 % moisture. The extract contains 25 % oil. The extract is distilled to recover the entire hexane in pure form leaving behind the oil, water and salts. The underflow is subjected to steam distillation which recovers 95 % hexane. For treating 100 kg seeds, calculate the following

a) The hexane used in kilograms.

b) % hexane used that is recovered from the underflow.

c) % recovery of oil.

4B. An evaporator system concentrating a weak liquor from 5 % to 50 % solids handles 100 kg of solids per hour. If the same system is to concentrate a weak liquor from 4 % to 35 %, find the capacity of the system in terms of solids that can be handled per hour assuming water evaporation capacity to be the same in both the cases. **[12+8 Marks]**

5. Sulphur dioxide reacts with oxygen producing Sulphur trioxide. In order to ensure complete reaction 100 % excess oxygen is supplied than that required theoretically. However only 75 % conversion is obtained. The pressure was 75 psi and temperature 750 K. 100 kg of Sulphur dioxide is charged to the converter. Determine the following

a) The volume of pure oxygen supplied at 2.5 bar and 350 K

b) The volume of Sulphur trioxide produced

c) The volume of gases leaving the converter

d) The composition of gases leaving the converter

e) The average molecular weight of the gas leaving the converter. **[20 Marks]**

6A. Calculate the standard heat of reaction at 298.15 K when gaseous ammonia is dissolved in water to form 2 % by weight ammonia solution.

Component	$\Delta H°_f$, kJ/mol
$NH_3(g)$	-49.94
$NH_4OH(l)$	-361.20
$H_2O(l)$	-285.83

6B. A stream of nitrogen flowing at a rate of 100 kmol/h is heated from 303 K to 373 K. Calculate the heat that must be transferred.
C_P for nitrogen = $29.5909 - 5.141 \times 10^{-3}\ T + 11.1829 \times 10^{-6}\ T^2 - 4.968 \times 10^{-9}\ T^3$ cal $mol^{-1}K^{-1}$

6C. When liquid benzene is completely burned to carbon dioxide and liquid water, the standard heat of combustion is -3267.6 kJ/mol. The standard heat of combustion of hydrogen to liquid water is -285.83 kJ/mol and that of carbon to CO_2 gas is -393.51 kJ/mol. Calculate the standard heat of formation of liquid benzene. **[7+6+7 Marks]**

7. Production of single-cell protein from hexadecane is described by the following reaction equation:

$$C_{16}H_{34} + aO_2 + bNH_3 \longrightarrow cCH_{1.66}O_{0.27}N_{0.20} + dCO_2 + eH_2O.$$

a) Determine a, b, c, d, and e if RQ = 0.75
b) Determine the yield coefficients, $Y_{X/S}$ and $Y_{X/O2}$
c) Determine degree of reduction for the substrate and bacteria **[20 Marks]**

8A. State the following laws:
a) Amagat's b) Dalton's c) Raoult's d) Henry's

8B. A distillation column separates 10,000 kg/hr of a 50% benzene and 50% toluene. The product recovered from the top contains 95% benzene while the bottom product contains 96% toluene. The stream entering the condenser from the top of the column is 8000 kg/hr. A portion of the product is returned to the column as reflux and the remaining withdrawn as top product. Find the ratio of the amount. **[10+10 Marks]**