Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER– III (NEW) EXAMINATION – SUMMER 2022

Subject Code:3130508 Date:18-07-2022

Subject Name:Material & Energy Balance Computation

Time:02:30 PM TO 05:00 PM Total Marks:70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

Q.1 **(a)** What is derived quantity? Give units of the following in terms of fundamental quantities: density and pressure. **03**

(b) Discuss importance of recycling and bypassing operations. **04**

(c) The average molecular mass of a flue gas sample is calculated by two different engineers. One engineer uses the correct molar mass of 28 for N_2 and determines the average molar mass to be 30.8, the other engineer, using an incorrect value of 14, calculates the average molar mass to be 20.3. i) Calculate the volume % of N_2 in the flue gases, ii) If the remaining components of the flue gases are CO_2 and O_2, calculate the volume % of each of them. **07**

Q.2 **(a)** Define the following terms: **03**
i) sensible heat ii) latent heat iii) heat capacity

(b) A force equal to 192.6 N is applied on a piston with a diameter of 5 cm. Find the pressure exerted by the piston in kPa, bar and psi. **04**

(c) Cracked gas from a petroleum refinery has the following composition by volume; methane 40%, ethane 10%, ethylene 25%, propane 10%, propylene 10%, n-butane 5%. Find: **07**
i) average molecular weight of the mixture,
ii) the composition by wt%, and
iii) density of the gas mixture

OR

(c) In case of liquids, the local heat-transfer coefficient for long tubes and using bulk-temperature properties is expressed by the empirical equation **07**

$$h = 0.023\, G^{0.8} k^{0.67} C_p^{\,0.33} / (D^{0.2} \mu^{0.47})$$

where h = heat-transfer coefficient, Btu/(h.ft^2.^{o}F)
G = mass velocity of liquid, lb/(ft^2.s)
C_p = heat capacity, Btu/(lb.^{o}F)
k = thermal conductivity, Btu/(h.ft.^{o}F)
D = diameter of tube, ft and
μ = viscosity of liquid, lb/(ft.s)

Convert the equation into SI units.

Q.3 **(a)** A sample of milliolite limestone, obtained from Porbandar, Gujarat, is found to contain 45.5% CaO (by mass). If this CaO is present as $CaCO_3$ in the limestone, find the content of $CaCO_3$ in the limestone. **03**

(b) A H_2SO_4 solution has a molarity of 11.24 and molality of 94. Calculate the density of the solution. **04**

(c) The feed to a continuous fractionating column analyzes by weight 28% benzene and 72% toluene. The analysis of the distillate shows 52% benzene and 5% benzene was **07**

found in the bottom product. Calculate the amount of distillate and bottom product per 1000 kg/h of feed. Also calculate the % recovery of benzene.

OR

Q.3 **(a)** Write the following equations with description of their terms: **03**
i) Watson equation ii) Riedel equation iii) NIST equation

(b) Aqueous solution of triethanolamine (TEA) of molar mass 149 contains 60% TEA by mass. Find the molarity of the solution if density of the solution is 1.5 kg/lit. **04**

(c) Give classification of fuel in brief. Define GCV and NCV for fuels. Give its importance. **07**

Q.4 **(a)** Define percentage conversion, percentage yield and selectivity. **03**

(b) Define the following terms with reference to air-water humidification operations: **04**
i) dry-bulb temperature, ii) wet-bulb temperature, iii) dew point, iv) absolute humidity

(c) Discuss ultimate analysis of coal. Give Dulong formula and Calderwood equation with nomenclature. **07**

OR

Q.4 **(a)** Find % excess of H_2 for $N_2 + 3H_2 \rightarrow 2NH_3$ reaction if for 100 kg of NH_3 production, H_2 fed is 30 kg. **03**

(b) In the production of sulphur trioxide, 100 kmol of SO_2 and 100 kmol of O_2 are fed to a reactor. If the percent conversion of SO_2 to SO_3 is 80%, Calculate the composition of product stream on mole basis. **04**

(c) A mixture of aniline and water containing 11.8% by weight of aniline is cooled from 100 ^oC to 40 ^oC with the help of cooling water. Find the amount of heat removed by cooling 100 kg of aniline-water mixture. **07**
The specific $C_p = a + bT + cT^2$ (kcal/kg.^oC)
where constants a, b, c are:
For aniline: a = 1.407, b = 2.467 x 10^{-3}, c = -6.08 x 10^{-6}
For water: a = 0.6741, b = 2.8 x 10^{-3}, c = 8.3 x 10^{-6}

Q.5 **(a)** With a neat sketch show the material balance for the following unit operations: **03**
i) Gas absorption, and ii) liquid-liquid extraction

(b) The feed water to reverse osmosis plant has dissolved solids to the extent of 5000 mg/L. The feed to product ratio (by mass) is 4:3. The treated water from the plant contains 600 mg/L of solids. Find the dissolved solids in the reject stream. **04**

(c) For o-xylene, calculate: **07**
i) latent heat of vaporization at T_B using Riedel equation, and
ii) latent heat of vaporization at 25 ^oC using Watson equation.
Data: P_C = 3732 kPa, T_C = 630.3 K, T_B = 417.6 K

OR

Q.5 **(a)** Define excess reactant, limiting reactant and recycle ratio. **03**

(b) The (GHV) gross heating value of gaseous propane is 2219.71 kJ/mol at 298.15 K. Calculate its NHV (net heating value) in kJ/mol and kJ/kg. Latent heat of water vapor at 298.15 K = 2442.5 kJ/kg. **04**

(c) 100 kg of Cadmium at 27^oC is to be melted. The heat is supplied by steam. Calculate mass of steam to be supplied. **07**
Data: melting point of Cadmium is 320.9^oC. atomic weight of Cadmium is 112.
$C_P = 6 + 0.005T$ kcal/kmol.^oC where T is in ^oC
latent heat of fusion = 2050 kcal/kmol
latent Heat of steam = 210 kcal/kg

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