Question Paper

MSK

Exam Date & Time: 01-Feb-2023 (09:30 AM - 12:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

THIRD SEMESTER B.TECH MAKE-UP EXAMINATIONS, JAN 2023

CHEMICAL PROCESS CALCULATIONS [CHE 2152]

Marks: 50 **Duration: 180 mins.**

Answer all the questions.

Instructions to Candidates: Answer ALL questions Missing data may be suitably assumed

1) (a) Calculate the conversion factor on converting the thermal conductivity from (4)

A) $\frac{BTU}{(hr).(ft).(^oF)}$ to $\frac{kJ}{(day).(m).(^oC)}$

(b) Convert the viscosity of 25 lb/(ft-h) to SI system

B) A chemical compound contain 54.05% Ca, 43.24% O and 2.71% H by weight basis. Find out the empirical formula and calculate the molecular weight of the compound (3)

C) The density of a 10 wt% solution of HCl is 1.06 g/cc. Calculate the molarity, normality and mole fraction. (3)

2) A liquid mixture of acetone (C_3H_6O) and water contain 0.2 kg acetone/kg water. Calculate the molality and mole fraction of acetone. (3)

A)

B) A flue gas has the following composition: CO: 34.8%, H_2: 42.0%, CH_4: 0.4%, CO_2: 5.5%, O_2: 0.2%, and N_2: 17.1% by mole basis. Evaluate the following: (4)

(a) The composition in weight percent

(b) The average molecular weight, and

(c) The density at standard conditions in kg/m^3

C) A crystallizer is charged with 9000 kg of an aqueous solution of 20% Na_2SO_4 (M.wt - 142) and it is subjected to evaporative cooling and 10% of original water evaporates. Glauber's salt ($Na_2SO_4.10H_2O$) crystallizes. The mother liquor leaves with 16% Na_2SO_4 . Calculate the amount of (3)

(a) Water loss,

(b) Mother liquor leaving and

(c) Crystals formed

3) 100 moles of a hydrocarbon mixture consisting of 20% ethane, 40% propane and 40% butane is admitted to the first column of a series of two distillation columns. The top product from this column contains 95% ethane, 4% propane and 1% butane. The bottom product enters the second column in the series where it is subjected to further purification. The distillate leaving the second column is (4)

A)

99% propane and 1% butane and the bottom product is 8.4% propane and 91.6% butane. Calculate (a) the quantity and composition of the bottom product from the first column and (b) the quantity of the distillate and bottom product from the second column.

B) An air-water vapour mixture at 101.3 kPa has a dry-bulb temperature of 313 K and is 40% saturated with water vapour. If the vapor pressure of water at 313 K is 7.37 kPa, calculate the: (4)

a) Absolute and molal humidity

(b) Dew point temperature,

(c) Wet bulb temperature, and

(d) % Relative saturation of the air

C) A wet granular material containing 80% water is dried in a rotary counter-current drier. The charge is admitted at one end and hot dry air is passed from the other end. In a typical operation, it is found that 100 kg of water is removed from the material giving a dry product containing 40% water. Calculate the amount of the wet material charged to the drier. (2)

4) A combustion chamber is fed with 50 kmol/h of butane and 2000 kmol/h of air. Calculate the % excess air used and composition of the gases leaving combustion reactor assuming complete combustion of butane. (3)

A)

Reaction: $C_4H_{10} + 13/2\ O_2 \rightarrow 4\ CO_2 + 5\ H_2O$

B) An experiment was carried out for the pyrolysis of rice hulls. A gas analyzed 6.4% CO_2, 0.1% O_2, 39% CO, 51.8% H_2, 0.6% CH_4, and 2.1% N_2 entered in a combustion chamber at 305 K and 120 kPa and was completely burnt with 40% excess air (dry). The dry air was supplied at 294 K and 100 kPa. Calculate the (a) volume of air supplied per cubic metre of gas entering, and (b) volume of product gas and its composition if the gas is leaving at 100 kPa and 477 K (3)

C) In the synthesis of ammonia fresh feed containing 24.75% nitrogen, 74.25% hydrogen and 1% inerts (on mole basis) is mixed with recycle feed. Mixed feed entering into the reactor resulted in 25% conversion to ammonia. The product mixture is passed through a condenser, where ammonia gets condensed and the remaining gases are recycled after purging a small portion of the gas stream to avoid build-up of the inerts. The recycle stream contains 12.5% of inerts. Calculate (4)

a. Recycle ratio (moles recycled per moles fed)

b. Purge ratio (Moles of purge per moles of recycle)

c. Overall conversion

5) The heat capacity of CO_2 is given by: (3)

A) $C_P = 26.45 + 42.45 \times 10^{-3}\ T - 14.298 \times 10^{-6}\ T^2$

where C_P is in J/mol K and T is in K. Calculate the (a) heat capacity at 400 K, (b) mean heat capacity between 300 K and 400 K, and (c) heat requirement for heating 88 kg of gas from 300 K to 400 K

B) Calculate the standard heat of reaction (ΔH°_{298}) for the reaction (3)

$C_2H_5OH \rightarrow CH_3CHO + H_2$

The standard heat of combustion of the compounds are as follows:

C_2H_5OH = - 1410 kJ/mol, CH_3CHO = - 1193 kJ/mol, and H_2 = - 286 kJ/mol

C) Using Hess's law calculate the heat of reaction (AH) for the following reaction? (4)

$CS_2(l) + 3O_2(g) = CO_2(g) + 2SO_2(g)$

Given:

$C(s) + O(g) = CO_2(g)$; $\Delta H_f = -393.5$ kJ/mol

$S(s) + O_2(g) = SO_2(g)$; $\Delta H_f = -296.8$ kJ/mol

$C(s) + 2S(s) = CS_2(l)$; $\Delta H_f = 87.9$ kJ/mol

-----End-----

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