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SF-6427

B. E. - II (Sem. IV) (Chemical) Examination

May / June - 2011

Process Calculation

Time : **3** Hours] [Total Marks : **100**

Instructions :

(1)

નીચે દર્શાવેલ ☛ નિશાનીવાળી વિગતો ઉત્તરવહી પર અવશ્ય લખવી.
Fillup strictly the details of ☛ signs on your answer book.

Name of the Examination :

☛ B. E. - 2 (SEM. 4) (CHEMICAL)

Name of the Subject :

☛ PROCESS CALCULATION

☛ Subject Code No. : 6 4 2 7 ☛ Section No. (1, 2,.....) : NIL

Seat No. :

Student's Signature

(2) Attempt all the questions.

(3) Figures to the right indicate full marks.

(4) Assume suitable data wherever necessary.

(5) Atomic wt. S=32, N=14, O=16, C=12, Cl=35.5, H=1

1 (a) Attempt the following : **2**x6=12

(i) Define Molarity and Normality.

(ii) Write down Vander Waals equation of state with units of constants.

(iii) Write Dalton's law and Amagat's law.

(iv) Define Rault's law

(v) What are the methods to solve material balance problem ?

(vi) Define limiting reactant and excess reactant.

(b) (i) Write a note : Recycling and Bypass operations. 8

(ii) Prove that volume % = Mole % for ideal gas.

2 Attempt the following : 8×2=16

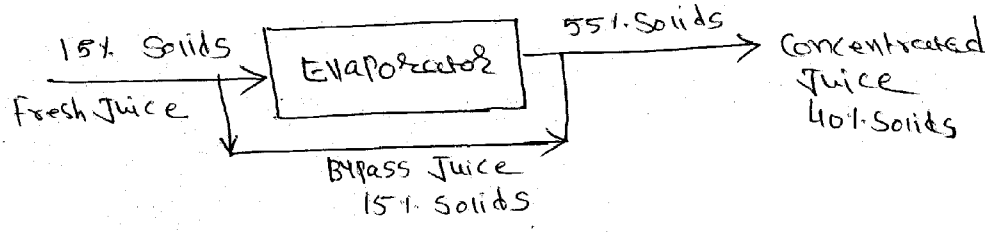
(a) Pure Sulphur is burnt in a burner at the rate of 0.3 kg/S. Fresh dry air is supplied at 30°C and 100 kPa a. The gases from the burner contain 16.5% SO_2, 3% O_2 and rest N_2 on SO_3 free volume basis. The gases leave the burner at 800°C and 101.325 kPa a. Calculate

(i) the fraction of sulphur burnt into SO_3

(ii) the percentage excess air over the amount required to oxidise the sulphur to SO_2

(iii) the volume of burner gases in m^3/S

(b) Fresh juice contains 15% solids and 85% water by weight and is to be concentrated to contain 40% solids by weight. In single evaporation system, it is found that volatile constituents of juice escape with water leaving the concentrated juice with a flat taste. To overcome this problem part of the fresh juice bypasses the evaporator. Operation is shown schematically in figure below.



(c) (i) The diameter and height of a vertical cylindrical tank are 5 ft and 6 ft 6 inch respectively. It is full upto 75% height with carbon tetra chloride (CCl_4), the density of which is 1.6 kg/L find the mass in kilograms.

(ii) Glycerin, weighing 600 mg, is dissolved in pure water to make a final solution of 1 litre. Find the TOC and THOD of the solution.

3 Attempt any two : **7×2=14**

(a) A 100 kg mixture of 27.8% of acetene (A) and 72.2% of chloroform (B) by mass is to be batch extracted with a mixed solvent at 25°C. The mixed solvent of an unknown composition is known to contain water (S_1) and acetic acid (S_2). The mixture of the original mixture and the mixed solvent is shaken well allowed to attain equilibrium, and separated into two layers. The composition of the two layers are given below.

Composition of immiscible layers composition, mass %

Layer	A	B	S_1	S_2
Upper Layer	7.5	3.5	57.4	3.16
Lower Layer	20.3	67.3	2.8	9.6

Find :

(a) The quantities of two layers

(b) The mass ratio of mixed solvent to original mixture

(c) The composition of mixed solvent (mass basis)

(b) Benzene reacts with nitric acid to produce nitrobenzene and water.

$$C_6H_6 + HNO_3 \xrightarrow{H_2SO_4} C_6H_5NO_2 + H_2O \rightarrow (1)$$

Nitrobenzene formed may undergo further nitration to form dinitro benzene

$$C_6H_5NO_2 + HNO_3 \xrightarrow{H_2SO_4} C_6H_4\left(NO_2\right)_2 + H_2O \rightarrow (2)$$

The percent conversion by benzene is 90 and acid is used 65% excess over theoretical requirement by reaction (1). If the mole ratio of nitrobenzene to dinitrobenzene in product steam is 17 : 1, calculate the quantities of benzene and nitric acid required for production of 2000 kg/K of nitro benzene.

(c) Cracked gas from a petroleum refinery contains 45%, CH_4, 10% C_2H_6, 25% C_4H_{10} by volume. Calculate

(i) the average molecular weight of gas mixture

(ii) the composition by weight and

(iii) the specific gravity of the mixture taking average molecular weight of air as 28.84.

4 Attempt the following : **18**

(a) Attempt all questions : **8**

(i) Define : Heat capacity

(ii) What is specific heat ?

(iii) Define : Latent heat of fusion

(iv) Define : Latent heat of vaporization.

(v) Define : Calorific value

(vi) What is incomplete combustion ?

(vii) What is heating value ?

(viii) Relation between NCV and GCV.

(b) The composition shown in below table are incoming and outgoing gas mixture and a converter. Assume that the sulphur burner gases enters the converter at 800 K and the outgoing gases leave it at 875 K. Cooling system installed in the catalyst beds of the converter.

Components	Inlet gas kmol/h	Outlet gas kmol/h
SO_2	8.851	0.351
O_2	13.200	8.950
SO_3	0.984	9.484
N_2	102.400	102.400
Total	125.435	121.185

Calculate at heat capacity data.

	a	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$
SO_2	24.7706	62.9481	–44.2582	11.122
O_2	26.0257	11.7551	–2.3426	–0.5623
SO_3	22.0376	121.624	–91.8673	24.3691
N_2	29.5909	–5.141	13.1829	–4.968

and $\Delta H_e^{\bullet} = -98910\, kJ/kmol$ SO_2 reacted.

5 Attempt any two : **8×2=16**

(a) Calculate the Std. heat of reaction at 25°C when gaseous ammonia is dissolved in water to form 2% by wt. of its solution for the regeneration of a weak anion exchanger of a water treatment plant.

NH_3 (g) + H_2O(l) $\rightarrow$ NH_4OH(l)

heat of formation at 25°C

for ammonia = –11.02 kcal/g mol

water = -68.315 kCal/g mol

Ammonium hydroxide = – 86.33 kCal/g mol.

(b) Flue gas leaving the stack of a boiler at 523°K have the following composition. CO_2 = 11.31%, H_2O = 13.04%, O_2 = 2.17% N_2 = 73.48%. Calculate the heat lost in 1 kg mol of the gas mixture above 298°K. Using the heat capacity data provided in below table.

	a	$b\times10^3$	$c\times10^6$	$d\times10^9$
CO_2	21.3655	64.2841	–41.0506	9.7999
H_2O	32.4921	0.0796	13.2107	–4.5474
O_2	26.0157	11.7551	–2.3426	–0.5623
N_2	29.5909	–5.141	13.1829	–4.968

(c) Discuss brief proximate and ultimate analysis of coal.

6 Attempt the following (any two) : **8×2=16**

(a) Aqueous monoethylene glycol (MEG) solution of 50% strength (by mass) is used as brine in a fine chemical plant. Hot brine from the plant enters tubes of a chiller at 50 L/S and is chilled from 263.15 K to 258.15 K in the shell of the chiller, refrigerant R-134 a evaporates at 249.15 k which is supplied from a receiver of a mechanical refrigeration system at 313.15 K through an expansion value. Density and specific heat of aqueous MEG solution are 1.08 kg/L and 3.08 kJ/(kmol.K) respectively in the desired temperature range. Calculate the flow of saturated vapours of R–134 a from the evaporator.

Data given :

Latent heat vaporation at

	h	H
temp	kJ/kg	
249.15	168.70	384.19
313.15	256.35	419.58

(b) Superheated steam is available at 0.5 MPa. a and 523 K calculate the quantity of water needed to be sprayed at 303 K for saturating 100 kg super heated steam.

Data : Enthalpy of superheated steam at 0.5 MPa P and 523 K = 2961 kJ/kg

Enthalpy of saturated steam at 0.5 MPa = 2747.5 kJ/kg

Enthalpy of water at 303 K = 126.09 kJ/kg.

(c) (i) Short note on heat capacity. **4**

(ii) Write step of energy balance with example. **4**