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MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

III SEMESTER B.TECH. (CHEMICAL ENGINEERING)

END SEMESTER EXAMINATIONS, NOVEMBER 2018

SUBJECT: CHEMICAL PROCESS CALCULATIONS [CHE 2101]

REVISED CREDIT SYSTEM

Time: 3 Hours (27th November 2018, FN) MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** questions.
- Missing data, if any, may be suitably assumed.
- Atomic Mass- Mg:24, O:16, N:14, S: 32, Na: 23, H:1, C:12, Ca:40, Cl:35.5, Cu: 63.5, P:31, Cr:52, K:39.

1A. Convert: **3**

i. The viscosity of water at 60°F is given as 20×10^{-4} lb ft^{-1} s^{-1}. Convert this viscosity in to N s m^{-2}.

ii. The thermal conductivity of aluminium is given as 50 Btu ft^{-1} h^{-1} $°F^{-1}$. Calculate this thermal conductivity in W m^{-1} $°C^{-1}$.

1B. An aqueous solution of HCl is 38% by mass and its density is 1.19 gm/ml. Calculate the normality, molarity & molality of the solution. **3**

1C. It is desired to have 100 kg of a mixed acid containing 40% HNO_3, 42% H_2SO_4 and 18% H_2O by weight. Sulfuric acid of an unknown composition and nitric acid of 69.5% are mixed to obtain the required composition given above. Calculate a) the strength of sulfuric acid b) mass of HNO_3 and H_2SO_4 required. **4**

2A. In a vessel at 1 bar and 300 K, the RH of water vapour in air is 25%. If partial pressure of water vapour when air is saturated with vapour at 300 K is 3.6 kN/m^2. **5**

Calculate

i) Partial pressure of water
ii) The humidity of air
iii) The percentage humidity
iv) The humid volume

2B. A solution of sodium chloride in water contains 38.5 parts of NaCl per 100 parts water by weight after the crystallization process. Calculate the weight of NaCl crystals that can be dissolved by 200 kg of the solution when heated to 65^{o}C (solubility at 65^{o}C is 37.265 kg of NaCl per 100kg water. **5**

3A Ethylene oxide is produced by the oxidation of ethylene with oxygen-enriched air: **4**

$C_2H_4 + ½\ O_2 \rightarrow C_2H_4O$

An undesired side reaction is the oxidation of ethylene to carbon dioxide:

$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$

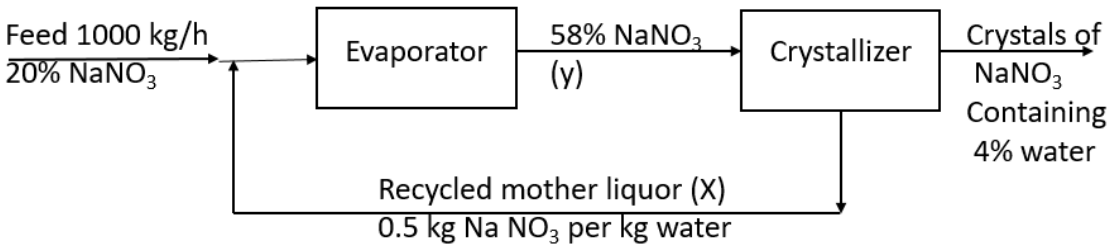
The feed stream to the ethylene oxide reactor consists of 45% (by mole) C_2H_4, 30% O_2, and 25% N_2. The amounts of ethylene oxide and carbon dioxide in the product stream are 20 gmol and 10 gmol per 100 gmol of feed stream, respectively. Determine

i) the composition of the exiting gas stream.
i) The percentage yield of C_2H_4O (defined as the percentage of C_2H_4 converted to C_2H_4O in the moles of C_2H_4 reacted)

3B The ultimate analysis of a coal sample is given below: **6**
Carbon = 61.5%, hydrogen = 3.5%, sulphur= 0.4%, ash= 14.2%, nitrogen= 1.8% and the rest oxygen.
Calculate:

i) The theoretical oxygen requirement per unit weight of coal
ii) The theoretical dry air requirement per unit weight of fuel and
iii) The Orsat analysis of flue gases when coal is burned with 90% excess dry air.

4A An aqueous solution containing 58% $NaNO_3$ from an evaporator is fed to a crystallizer. The crystals obtained from the crystallizer contain 4% water (crystals of $NaNO_3$ carry off 4% water). The mother liquor from the crystallizer is recycled to the evaporator after mixing with 1000kg/h of fresh feed containing 20% $NaNO_3$. The mother liquor contains 0.5 kg of $NaNO_3$ per kg of water. **5**



Calculate i) the yield of crystals ii) the mass flow rate of the recycled mother liquor iii) the composition of the mixed feed entering the evaporator and iv) the total feed rate to the evaporator. (All percentages are by weight).

4B Dry methane is burnt with dry air and both are initially at 25^{o}C. The theoretical flame temperature is 1327 ^{o}C. Complete combustion is assumed. How much of excess air is used? **5**

$\Delta H^{o}_{R} = -0.2x\ 10^{6}$ cal
Mean specific heat capacity, Cpm Cal/(mol ^{o}C): CO_2=12.37, H_2O = 9.6; N_2=7.68; Air=7.7

5A Calculate the heat of reaction at 500 K for the reaction **5**
$SO_2 + ½ O_2 \rightarrow SO_3$.
Standard heats of formation (in Kcal/ gmol):
SO_2 = -70944, SO_3 = -94580

	α	β x10^3	γ x10^7
SO_2	6.147	13.84	-91.03
O_2	6.732	1.505	-1.791
SO_3	6.077	23.537	-96.87

5B The standard heats of the following combustion have been determined experimentally **5**
C_5H_{12} (g) +8O_2 (g) → 5CO_2 (g) + 6H_2O (l)

The following are the heat of formation of the substances at 298 K

Substance	ΔH^o (kJ / mol)
Pentane (g)	-146.76
Carbon dioxide (g)	-393.5
Water (l)	-285.8

i) Calculate the ΔH^o_R for the above reaction
ii) Determine the the Higher Heating Value and the Lower Heating Value of pentane in kJ/kg

Data: Latent heat of vaporization of water = 2442.5 kJ/kg at 25 ^oC

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