MANIPAL INSTITUTE OF TECHNOLOGY

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III SEMESTER B.TECH. (CHEMICAL ENGINEERING)

END SEMESTER EXAMINATIONS, NOVEMBER 2017

SUBJECT: CHEMICAL PROCESS CALCULATIONS [CHE 2101]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** questions.
- Missing data, if any, may be suitably assumed.
- Atomic Mass- Mg:24.3, O:16, N:14, S: 32, Na: 23, H:1, C:12, Ca:40, Cl: 35.5, Cu: 63.5, P:31, Cr:52, Fe:59
- Use of humidity chart is permitted

(23rd November, 2017, FN)

1A.	Convert: i. 1 lb-mol/hr to 1 g-mol/day ii. 5 kcal/hr.m^2.^oC to Btu/hr. ft^2. °F. iii 1000 Watt/m^2 to cal/sec.cm^2	**2+2+1**
1B.	Provide answers to the following four questions: a) How many grams of KBr will be needed to make 500 mL of a 2-M solution? (Atomic weight K: 39.1; Br: 79.9) b) How many milliliters of water must be added to 5 mL of a 12-M HCl solution to make a 6-M HCl solution? c) How many milliliters of a 2-M HCl solution is necessary to neutralize 2 mL of a 0.5- M NaOH solution? d) What is the molarity of a H_2SO_4 solution that contains 33.3% H_2SO_4 by weight and has a density of 1.25 g/mL?	**5**
2A.	100 kg of an aqueous solution of pyridine containing 20% by weight pyridine and 80% water is to be extracted with chlorobenzene. After bringing the solvent and feed in contact in a contacting device, the two phases are allowed to separate. The extract phase contains 12 % pyridine and 87 % chlorobenzene and 1% water whereas the raffinate phase has 5% pyridine and 95% water by weight. Calculate i. The mass of extract and raffinate phases formed ii. The weight ratio of solvent to feed ratio used.	**5**
2B.	Iron pyrites ore containing 80% FeS_2 and 20% nonvolatile inert is roasted with an amount of 80% excess air. The reaction is $4FeS_2+11O_2 \rightarrow 2Fe_2O_3+8SO_2$ The solid residue contains 4% FeS_2 by wt. Based on 1 ton of ore charged calculate the extent of reaction and volumetric composition of gases obtained.	**5**

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3A. Air at a temperature of 313K and pressure of 730 mmHg abs. has a relative humidity of 80%. Calculate **05**

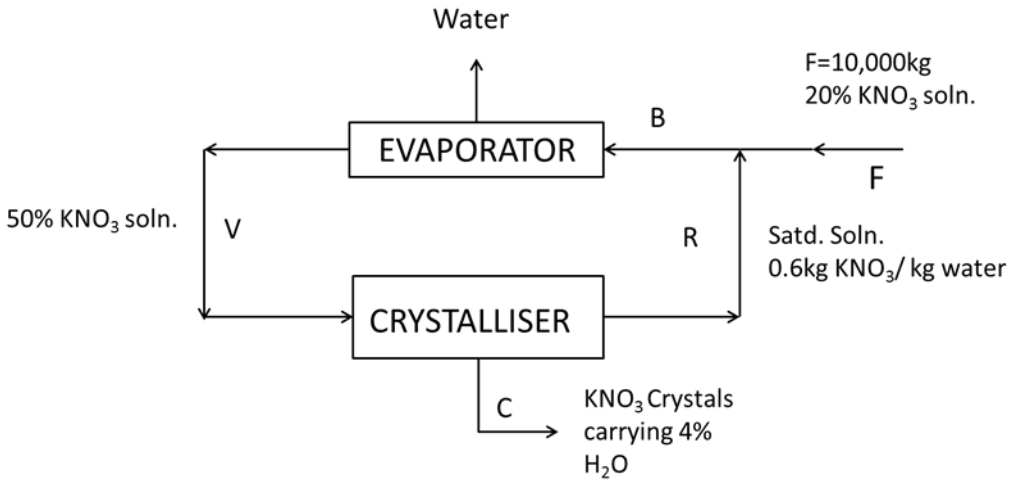
i. The absolute humidity of the air.
ii. The absolute humidity of this air if the temperature is reduced to 288K and the pressure is increased to 2 atm abs. condensing out some water,
iii. The weight of water condensed during cooling and compression from 100 kg of wet air feed.

(vapour pressure of water at 313 K and 288 K may be obtained from humidity chart)

3B. A tank holds 10,000 kg saturated solution of $NaHCO_3$ at 60°C. It is required to crystallize 500 kg of $NaHCO_3$ from this solution. To what temperature the solution must be cooled? Data: **5**

Temp (°C)	60	50	40	30	20	10
Solubility $\left[\frac{g\ NaHCO_3}{100\ g\ water}\right]$	16.4	14.45	12.7	11.11	9.6	8.15

4A. **5**



A feed solution having KNO_3 concentration of 20% by weight is processed to obtain KNO_3 crystals as shown in the scheme above. Determine the ratio of R to F.

4B. A producer gas with composition by volume is as follows: **5**

CO=27.5% ; CO_2=5.3% ; O_2= 0.7% ; N_2= 66.5%

It is burnt with 20% excess air. Calculate the composition by mole fraction of flue gas.

5A. A power plant is burning anthracite coal containing 7.1% ash to provide the necessary energy for steam generation. If 660 ft^3 of total flue gas are produced for every kg of coal burned and if all the ash present in coal is carried away in the flue gas, what is the **5**

	maximum effluent particulate matter present in μg/m^3? Assume no contribution to the particulates from any other waste. The stipulated air quality standard for particulates is 75 μg/$m^{3.}$ If fresh air is to be mixed with flue gas, what dilution factor is required to achieve this standard? If the particulate matter is removed without dilution by fresh air, what percentage removal of particulate matter is required?	
5B.	A natural gas has the following composition on mole basis. CH_4= 83%; C_2H_6 = 15%; N_2= 2%. Calculate the heat to be added to raise the temperature of this gas from 300 K to 520 K using the heat capacity data given below. $C_p = a + bT + cT^2$ kJ/kgmol.K	**5**

Component	a	$bx10^3$	$cx10^3$
CH_4 (g)	19.26	52.12	11.98
C_2H_6 (g)	5.41	178.09	−67.38
N_2 (g)	29.60	−5.15	13.19