BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: B.TECH **SEMESTER : III**
BRANCH: CHEM.& POLY / CHEM.ENGG **SESSION : MO/19**

SUBJECT: CL204 CHEMICAL PROCESS CALCULATION

TIME: 3 HOURS **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

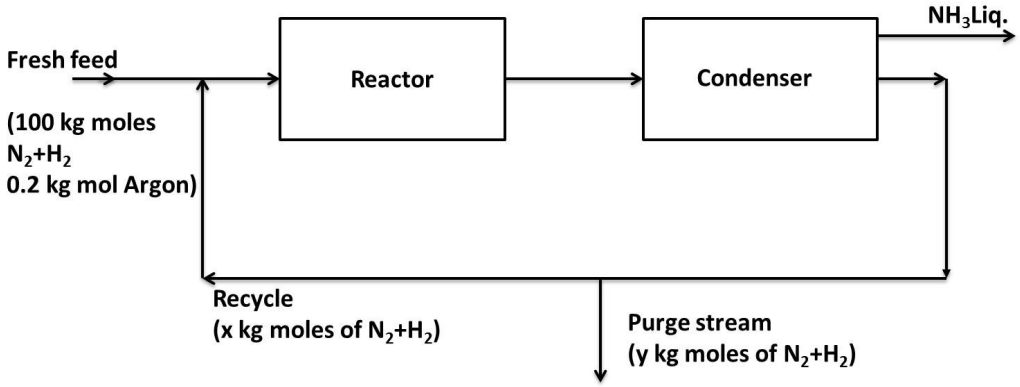
Q.1(a) The effective heat capacity of a mixture of gases is given by [5]
$C_p = 7.13 + 0.577 \times 10^{-3} t + 0.0248 \times 10^{-6} t^2$
Where C_p is in Btu/(lb-mol °F) and t is in °F
(a) What are the units of the constants in the equation?
(b) Change the equation into the form in which C_p is given in KJ/(Kmol K) and temperature is in K

Q.1(b) The pressure difference ΔP in a pipe of diameter D and length l due to turbulent flow depends on the velocity V, viscosity μ, density ρ, roughness k, Using Buckingham's Pi-theorem, find an expression for ΔP. [5]

Q.2(a) A producer gas has the following composition by volume CO-23%, CO_2-4.4%, O_2-2.6% and Rest is N_2(70%). [5]
(i) Determine the cubic ft of gas at 70°F and 750 mm of Hg pressure per lb of carbon present.
(ii) Determine the volume of air at the condition of part (i), required for the combustion of 100 cubic ft of gas at the same conditions, if it is desired that the total oxygen present before combustion shall be 20% in excess of that theoretically required.

Q.2(b) Soyabean seed are extracted with hexane in batch Extracter. The flaked seed contain 18.6% oil, 69.0% solid and 12.4 % moisture. At the end of the process, cake of milk is separated from the hexane oil mixture. The cake analysis yield 0.8% oil, 87.7% solid and 11% moisture. Find the % recovery of oil. All % are by wt only. [5]

Q.3(a) Nitrogen hydrogen mixture with a molar ratio of 1:3 is used for the manufacture of NH_3, where 18% conversion is achieved. After separating NH_3 from product, the unconverted gases are recycled. The feed contains 0.2 mole of Argon per 100 moles of N_2-H_2 mixture. The toleration limit of Argon entering the reactor is 6 parts to 100 parts of N_2-H_2 mixture by volume. Determine the fraction of recycle that must be continually purged. (Hint: At steady state Argon purged is equal to the Argon in fresh feed) [5]



Q.3(b) A solute of $K_2Cr_2O_7$ in water contains 15% by wt $K_2Cr_2O_7$. Determine the amount of $K_2Cr_2O_7$ that can be produced from 1500 Kg of solution if 700 Kg of water is evaporated and remaining solution is cooled to 20°C. The solubility of $K_2Cr_2O_7$ at 20°C is 115 Kg/1000 Kg of water. [5]

Q.4(a) 1000 kg of mixed acid of composition 40% H_2SO4, 45% HNO_3 and 15% H_2O is to be produced by strengthening waste acid of composition 30% $H2SO_4$, 36% HNO_3 and 34% H_2O by weight. Concentrated sulphuric acid of strength 95% and concentrated nitric acid containing 80% are available for this purpose. How many kilograms of spent acid and concentrated acids are to be mixed together? [5]

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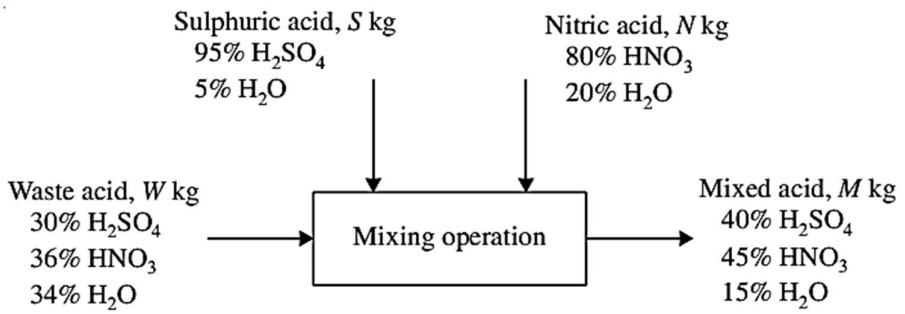
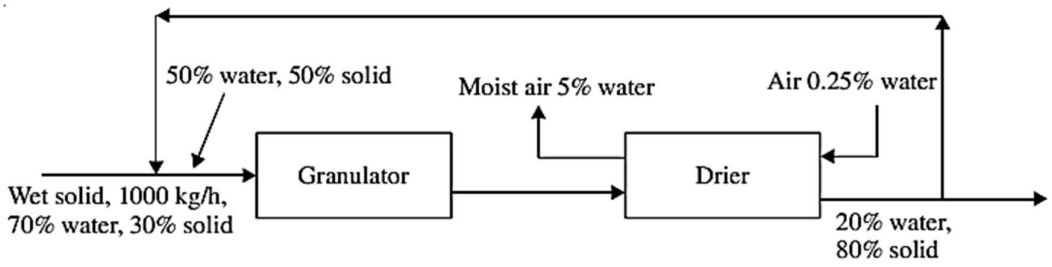


Q.4(b) Wet solid containing 70% water is mixed with recycled dry solid to reduce the water content to 50% before being admitted into the granulator (Figure). The solid leaving the granulator is fed to a drier where it is brought into contact with dry air initially containing 0.25% water by weight. In the drier the air picks up moisture and leaves with a moisture content of 5%. The solids leaving the drier contains 20% water. A portion of this solid is recycled. [5]

For 1000 kg/h of wet solid sent to the granulator as fresh feed, determine the following:

(a)The amount of solid recycled

(b) The circulation rate of air in the drier on a dry basis



Q.5(a) Determine the heat of reaction for the esterification of ethyl alcohol with acetic acid if the standard heats of combustion are: ethyl alcohol (l), – 1366.91 kJ/mol; acetic acid (l), – 871.69 kJ/mol; ethyl acetate (l), –2274.48 kJ/mol. [5]

Q.5(b) The vapour-phase hydration of ethylene to ethanol is represented by: [5]

$$C_2H_4(g) + H_2O(g) \rightarrow C_2H_5OH(g)$$

Calculate the standard heat of reaction if the following data are available:

$$2CO_2(g) + 3H_2O(l) \rightarrow C_2H_5OH(l) + 3O_2(g) \quad \Delta H^0_{298} = 1366.91 \text{ kJ}$$

The standard heat of combustion of ethylene at 298 K is -1410.99 kJ/mol and heats of vaporization of water and ethanol are, respectively, 44.04 kJ/mol and 42.37 kJ/mol.