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MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

III SEMESTER B.TECH. (CHEMICAL ENGINEERING)

MAKEUP EXAMINATIONS, DECEMBER 2018

SUBJECT: CHEMICAL PROCESS CALCULATIONS [CHE 2101]

REVISED CREDIT SYSTEM

Time: 3 Hours (29th December 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. 1500 km^3/ yr to m^3/day

ii. 10 BTU/lb^oF to kJ/kg^oC

1B Two engineers are calculating the average molecular wt. of gas mixture containing O_2 and other gases. One uses the correct mol.wt. of 32 and finds the avg. mol. wt. as 37.6. The other uses an incorrect value of 16 and determines the avg. mol. wt. as 32.8. What is the % of O_2 in the mixture. **2**

1C. Answer the following: **5**

i. How many moles are there in 50.0 g of DMSO (Di-Methyl Sulfoxide)- $(CH_3)_2$ SO?

ii. If the specific gravity of DMSO is 1.1, what is the density in g/cm^3?

iii. What is the volume occupied by 50.0 g of DMSO in cm^3 and ft^3?

iv. How many molecules are contained in 50.0 g of DMSO?

2A. A solution containing 23 per cent by mass of sodium phosphate is cooled from 313 to 298 K in a Swenson-Walker crystalliser to form crystals of $Na_3PO_4.12H_2O$. The solubility of Na_3PO_4 at 298 K is 15.5 kg/100 kg water, and the required product rate of hydrated crystals is 200 kg/h. Determine the mass flow rate of feed required and the flow rate of mother liquor. **5**

2B. Brick material containing 70% moisture is to be dried at the rate of 0.15 kg/s in a counter current drier to give a product containing 5% moisture (both on wet basis). The drying **5**

medium consists of air heated to 373 K, at an absolute pressure of 1 atm with moisture having a partial pressure of 1 kN/m^2. The air leaves the drier at 313 K and 70% humidity. Calculate the amount of air required. The vapour pressure of water at 313 K is 7.4 kN/m^2.

3A Pure CO_2 can be prepared by treating limestone with aq. H_2SO_4. The limestone used contains $CaCO_3$, $MgCO_3$ and inerts. The acid used contains 12% H_2SO_4. The residue from the process had the following combinations. **5**

$CaSO_4$:8.56%, $MgSO_4$:5.23%, H_2SO_4:1.05%, Inerts:0.53%, CO_2: 0.12%, water: 84.51%

During the process, CO_2 and water vapors are distilled. Calculate:

i) The analysis of limestone.

ii) % excess of acid used.

3B It is desired to make a 24% by wt. of caustic soda solution. It is done in 2 steps. **5**

i. The caustic soda is dissolved in a dissolution tank in a correct quantity of water to produce 50% solution.

ii. After complete dissolution, the solution is taken to a dilution tank, where some more water is added to produce 24% by wt. of solution.

Calculate the wt. ratios of water added in step i) and step ii)

4A Analysis of flue gas obtained from a gas containing no N_2 is given as follows: **6**

CO_2=4.62%, CO=3.08%, O_2=8.91%, N_2=83.39%

i) Calculate the moles of dry air per mole of dry flue gas

ii) % excess air

iii) Net H_2 burned per mole of dry flue gas

iv) Kg of fuel burnt/mole of dry flue gas

v) Analysis of fuel gas which is a mix of CH_4 and C_2H_6

4B Calculate the standard heat of reaction ΔH^o_R for the reaction **4**

$2FeS_2 + 11/2O_2 \rightarrow Fe_2O_3 + 4SO_2$

The standard heat of formation of the compounds are

Components	ΔH^o_F kJ/mole
FeS_2	-178.03
O_2	0
Fe_2O_3	-822.75
SO_2	-297.11

5A Urea is produced as per the following reaction **5**

$2\ NH_3+CO_2 \rightarrow NH_2COONH_4$

$NH_2COONH_4 \rightarrow NH_2CONH_2+H_2O$

If conversion per pass of NH_3 to NH_2COONH_4 is 60% and 5000 kg of urea is to be produced, Find

i. Volume of NH_3 to be fed at STP

ii. The amount of H_2O produced

5B The flue gases are leaving the chimney of a boiler at 300^{o}C the molar composition of which are as follows. CO_2=11.3%, CO=0.26%, H_2O=13.04%, O_2=2%, N_2=73.4%. **5**

Calculate Q in 1 kg mole of gas mixture above 25^{o}C using the following C_p data kcal / (kg mole ^{o}K)

CO_2= 6.396+ 10.1 x 10^{-3} T - 3.354 x 10^{-7} T^2

CO=6.48+ 1.566 x 10^{-3} T – 2.359 x 10^{-7} T^2

H_2O=6.732+ 1.505 x 10^{-3} T – 1.791 x 10^{-7} T^2

O_2=6.97+ 3.464 x 10^{-3} T – 4.83 x 10^{-7} T^2

N_2=6.529+ 1.448 x 10^{-3} T – 3.271 x 10^{-7} T^2