| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |

# MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

*A Constituent Institution of Manipal University*

**III SEMESTER B.TECH. (CHEMICAL ENGINEERING)**

**MAKE-UP EXAMINATION, DEC/JAN 2016**

SUBJECT: CHEMICAL PROCESS CALCULATIONS [CHE 2101]

**REVISED CREDIT SYSTEM**

Time: 3 Hours MAX. MARKS: 100

**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

| | | |
|---|---|---|
| **1A.** | Convert :<br>i. Density of 15 gm/cc to $kg/m^3$<br>ii. Viscosity of 7.5 cp to lbm/ft.hr.<br>iii. Mass flow rate of 100 $lb/hr.ft^2$ to $kg/sec.m^2$<br>iv. 2 kcal/hr into watts | **10** |
| **1B.** | A solution of Caustic Soda (NaOH) in water contains 20% by wt. of NaOH at 333K. The density of the solution is 1.196 kg/lit. Find the molarity, normality and molality of the solution. | **10** |
| **2A.** | A solution containing sodium sulfate in water is crystallized out by cooling the solution to $5^oC$. The original solution is saturated to $40^oC$ and deca-hydrate crystals are obtained. Estimate the wt. of crystal obtained by cooling a batch of 2000 kg of this solution.<br>Solubility at $40^oC$= 32.6 %<br>Solubility at $5^oC$= 5.75 %<br>Both solubilities have units of kg $Na_2SO_4$/ kg solution<br>( Molecular Wts: $Na_2SO_4$=142 , $Na_2SO_4.10H_2O$= 322) | **10** |
| **2B.** | A waste acid from a nitration process contains 21 % $HNO_3$, 55 % $H_2SO_4$, and 24 % water. The acid is to be concentrated to contain 28 % $HNO_3$, 62% $H_2SO_4$ by wt. by the addition of conc. $H_2SO_4$ and $HNO_3$ having concentrations 93 % and 90% by wt. respectively. Calculate the weight of the waste acid and conc. acid required to obtain a product of 1000kg. | **10** |

| | | |
|---|---|---|
| **3A.** | Determine the flue gas analysis and air-fuel ratio by wt. when a fuel oil with 84.5% C, 11.8% $H_2$, 3.2 % S, 0.4% $O_2$, 0.1% ash is burned with 25% excess air. | **10** |
| **3B.** | Solid material with 15% water is to be dried to 7% water under the following conditions:<br>Fresh air is mixed with recycled air and is blown over the solid. The humidity of fresh air =0.01 kg water/ kg of dry air and the recycled air has a humidity=0.1 kg of water/ kg of dry air. They are mixed in such a way that the entering mix to the drier has a humidity of 0.03 kg water/ kg dry air.<br>Calculate<br>i. Kg of dry air/ 100 kg of wet material<br>ii. Kg of water removed/ kg of feed<br>iii. Ratio of recycled air to fresh air<br>If fresh air enters at 60$^oC$ and 10 atm, find the volume of the air entering. | **10** |
| **4A.** | Antimony (Sb) is obtained by heating pulverized Stibinite ($Sb_2S_3$) with a scrap iron and drawing of the molten antimony from the bottom of the reaction vessel.<br>Suppose that 0.6 kg of stibinite and 0.25 kg of iron turnings are heated together to give 0.2 kg of antimony metal.<br>Calculate:<br>i. The limiting reactant<br>ii. % excess reactant<br>iii. Degree of completion<br>iv. % conversion<br>Given: Mol Wt.: Stibinite= 339.7; Antimony=121.85; Fe= 55.85 | **10** |
| **4B.** | $N_2$ and $H_2$ mixed in a mole ratio of 1:3 is used for manufacturing $NH_3$. The conversion per pass is 16%. Ammonia is separated and the unconverted gases are recycled. The feed contains 0.2 moles of Argon per 100 moles of $N_2$ and $H_2$ mix by volume. The tolerance limit of Argon entering the reactor is 6 parts per 100 parts of $N_2$ and $H_2$ mix by volume.<br>Calculate:<br>i. The fraction of the recycle that must be continuously purged.<br>ii. Recycle ratio | **10** |
| **5A.** | The flue gases are leaving the chimney of a boiler at 300$^oC$ 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%.<br>Calculate Q in 100 kg mole of gas mixture above 25$^oC$ using the following $C_p$ data (kcal / kg mole $^oK$)<br>$CO_2= 6.396+ 10.1 \times 10^{-3} T - 3.354 \times 10^{-7} T^2$<br>$CO=6.48+ 1.566 \times 10^{-3} T – 2.359 \times 10^{-7} T^2$<br>$H_2O=6.732+ 1.505 \times 10^{-3} T – 1.791 \times 10^{-7} T^2$ | **10** |
| **5B.** | Liquid methanol is burnt with 100 % excess air, methanol is fed at 25$^oC$ and air enters at 100$^oC$. assume complete combustion and calculate the highest temperature that the furnace wall will have to withstand.<br>$\Delta H_R^o$= -726.6 kJ/mole.<br>Cp of air at 100$^oC$ = 29.1 J/mole.<br>Cp (J/mole K)<br>$CO_2= 36.11+ 4.233 \times 10^{-2} T - 2.887 \times 10^{-5} T^2$<br>$H_2O= 33.46+ 0.688 \times 10^{-2} T + 0.7604 \times 10^{-5} T^2$<br>$O_2= 29.1+ 1.158 \times 10^{-2} T - 0.6076 \times 10^{-5} T^2$<br>$N_2= 29.0+ 0.22 \times 10^{-2} T +0.5723 \times 10^{-5} T^2$<br>Latent heat of vaporization = 44.013 kJ/mole<br>$CH_3OH (l) + 3/2 O_2 \rightarrow CO_2 + 2 H_2O (l)$ | **10** |