S.E - III Sem - Biotech 21/12/15

Process Calculation

(25) SE/III/CBGS/BT/PC

QP Code : 5295

(3 HOURS) [TOTAL MARKS: 80]

Note:

1. Question No. 1 is compulsory.
2. Attempt any three questions out of remaining five questions.
3. Assume suitable data wherever necessary.
4. Figures to right indicate full marks.

Q.1 a. State the reasons for using a recycle stream in a chemical process. 5

b. A certain organic compound is found to contain 81.5% C, 4.9% H and 13.6% N by weight. If the molecular weight of the compound is 103, Determine the molecular formula of the compound. 10

c. Give material balance equation for distillation operation. 5

Q.2 a. The waste acid from a nitrating process contains 23% HN03 ; 57% H2S04 and 20% water. This acid is to be concentrated to 27% HN03 ; 60% H2S04 by addition of 93% H2S04 and 90% HN03 . Calculate the weight of acids needed to obtain 1000 kg of desired acid 10

b. A combustion reactor is fed with 50 kmol/h of butane and 2000 kmol/h of air. Calculate the % excess air used and composition of the gases leaving combustion reactor assuming complete combustion of butane. 10

Q.3 a. The ultimate analysis of a coal sample is given:Carbon = 61.5%, Hydrogen = 3.5%, Sulphur = 0.4%, Ash = 14.2%, Nitrogen = 1.8% and the rest oxygen. 15

Calculate:

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

b. Prove: mol% = vol% = p% 5

Q.4 In synthesis of ammonia, the fresh feed containing 24.75% nitrogen, 74.25% hydrogen and 1% inerts (on mole basis) is mixed with recycle feed. Mixed feed entering into reactor resulted in 25% conversion to ammonia. The product mixture is passed through condenser, where ammonia gets condensed and the remaining gases are recycled after purging small portions of gas stream to avoid build up of inerts. The recycle stream contains 12.5 mole % inerts. 20

Calculate: (a) recycle ratio, (b) purge ratio and (c) combined feed ratio.

[P.T.O.]

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Q.5 a. Obtain an empirical expression relating the heat of reaction and the temperature of the reaction for the following reaction: 10

$SO_2 (g) + ½ O_2 (g) \rightarrow SO_3 (g)$

Using the same expression, calculate the heat of reaction at 773 K (500° C).

Data:

Component	ΔH_f°, kJ/kmol
SO_3 (g)	-395720
SO_2 (g)	-296810

$C_p^\circ = a + bT + cT^2 + dT^3$, kJ/(kmol.K)

Component	A	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$
SO_3	22.036	121.624	-91.867	24.369
SO_2	24.771	62.948	-44.258	11.122
O_2	26.026	11.755	-2.343	-0.562

b. The composition of gas mixture in manufacture of nitric acid at a pressure of 0.709 MPa g and 923 K (650° C) is as follows: 10

$N_2 = 70.5\%$, $O_2 = 18.8\%$, $H_2O = 1.2\%$ and $NH_3 = 9.5\%$

Calculate the density of gas mixture using ideal gas law.

Q.6 a. Assume that experimental measurements for a certain organism have shown that cells can convert two-thirds (wt/wt) of the substrate carbon (alkane or glucose) to biomass. 14

(i) Calculate the stoichiometric coefficients for the following biological reactions:

Hexadecane: $C_{16}H_{34} + aO_2 + bNH_3 \rightarrow c(C_{4.4}H_{7.3}N_{0.86}O_{1.2}) + d\,H_2O + e\,CO_2$

Glucose: $C_6H_{12}O_6 + aO_2 + bNH_3 \rightarrow c(C_{4.4}H_{7.3}N_{0.86}O_{1.2}) + d\,H_2O + e\,CO_2$

(ii) Calculate the yield coefficient $Y_{X/S}$ (g dw cell/g substrate), $Y_{X/O2}$ (g dw cell/g O_2) for both reactions. Comment on the differences.

b. Define: (i) Bypassing and purging 6

(ii) Partial Pressure

(iii) Heat Capacity