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SE-8043

B. E. - II (Sem. III) (Chemical) Examination

April / May - 2011

Process Calculation

(New Syllabus)

Time : **3** Hours] [Total Marks : **100**

Instructions :

(1)

નીચે દર્શાવેલ ☛ નિશાનીવાળી વિગતો ઉત્તરવહી પર અવશ્ય લખવી.
Fillup strictly the details of ☛ signs on your answer book.

Name of the Examination :

☛ **B. E. - 2 (SEM. 3) (CHEMICAL)**

Name of the Subject :

☛ **PROCESS CALCULATION (NEW)**

☛ Subject Code No. : **8 0 4 3** ☛ Section No. (1, 2,.....) : **NIL**

Seat No. :

Student's Signature

(2) Answer all the questions.

(3) Figures on right indicate full marks.

(4) Atomic weights are : C=12, H=1, O=16, N=14, S=32

(5) Use of Scientific calculator is permitted.

1 (a) Give the answer : 8

(1) What is limiting component ?

(2) What is excess reactant ?

(3) Define : Mole

(4) 1 kg = _____ lb.

(5) Find molecular weight of monoethanol amine ($NH_2CH_2CH_2OH$)

(6) What is conversion ?

(7) What is yield ?

(8) What is stoichiometric number ?

(b) In the preparation of cooking liquor for a sulphite pulp mill, an absorption column is used to absorb SO_2 in a weak liquor. The weak liquor enters the top of the column at the rate of 20 L/S with SO_2 concentration of 0.5% (by mass) and leaves with SO_2 concentration of 1.0% (by mass). The gas stream entering the bottom of the column passing in the counter-current direction to the liquor stream contains 17.0% (by volume) SO_2. When the gas leaves the top of the column, 75% of SO_2 gets absorbed. the pressure in the column becomes 50 KPa g and operates isothermally at 308 K. Assuming that the liquor has a specific gravity of 1.0, calculate : **10**

(a) the molar flow rate of entering gas

(b) the volumetric flow rate of entering gas in dm^3/sec.

2 Attempt any **two** : **16**

(a) In a textile industry it is desired to make a 24% solution (by mass) of caustic soda for a mercerizations process. Due to the very high heat of dissolution of caustic soda in water, the above solution is prepared by two-step process. **8**

First, in a dissolution tank, caustic soda is dissolved in the correct quantity of water to produce 50% (by mass) solution. After complete dissolution and cooling, the solution is taken to dilution tank where some more water is added to produce 24% solution. The two step process is shown in below figure.

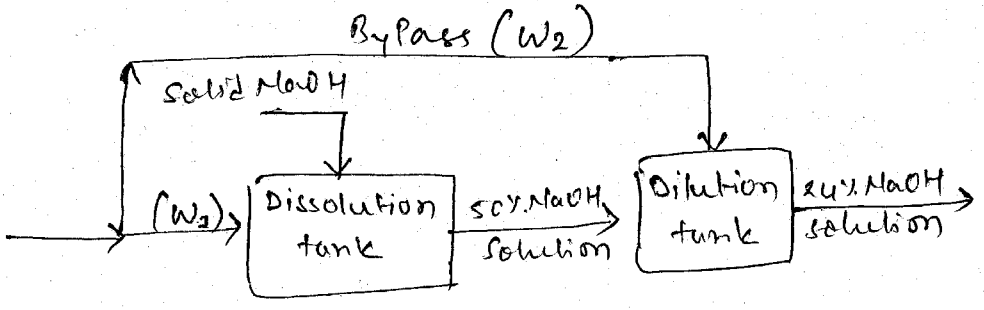
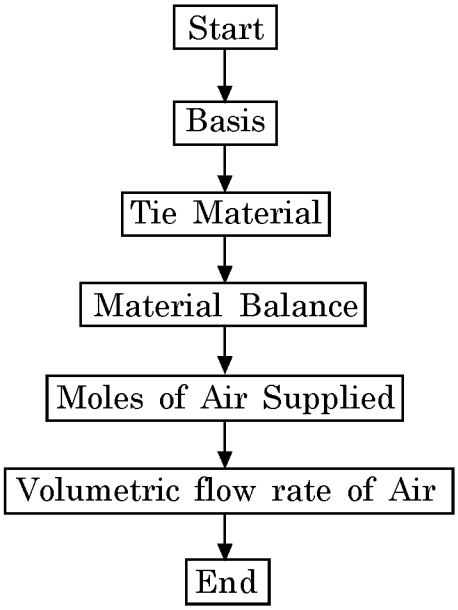


Fig.

Assuming no evaporation loss in the dissolution tank, calculate the mass ratio w_1/w_2.

(b) Slabs of buildings boards contain 16% moisture. They are dried to a water contain of 0.5% by circulating hot air over them. The fresh air contains 0.02 kg water vapour per kg dry air. The exhaust air contains 0.09 kg water vapour per kg dry air. If the fresh air is supplied at 28°C and 760 mm Hg. Flow chart to calculate the quantity of fresh air (in m^3/hr) required per 1000 kg/hr. net dry board is given below. List out the steps followed for above calculation. 8



(c) A spent lye sample obtained from a soap-making unit contains 9.6% glycerol and 10.3% salt (NaCl). It is concentrated at the rate of 50,000 kg/hr in a double effect evaporator until the final solution contains 80% glycerol and 6% salt. Assume that about 4.5% glycerol is lost by entrainment. All percentage are by mass. Find : 8

(i) The evaporation taken place in the system.

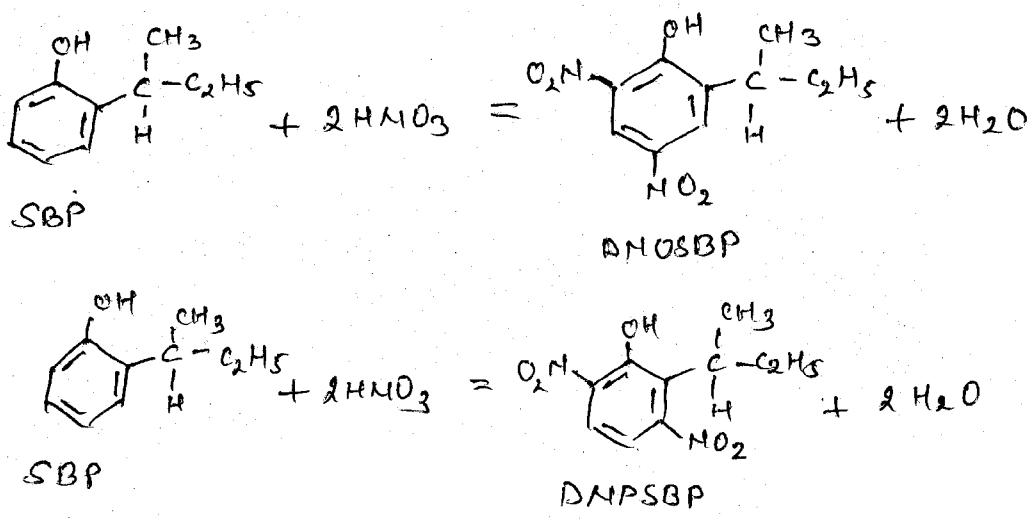
(ii) The amount of salt crystalised out in the salt box of the evaporator.

3 Attempt any **two** : **16**

(a) What will be the composition of gases obtained by burning pure FeS_2 with 60% excess air ? Assume that the reaction proceeds in the following manner. **6**

$$4FeS_2 + 11O_2 = 2Fe_2O_3 + 8SO_2$$

(b) Dinitro-o-sec-butyl phenol (DNOSBP) is manufactured by the nitration of sec-butyl phenol (SBP) in presence of zinc chloride and hydrogen chloride. **10**



After the reaction is complete, a sample from the reactor is analysed as follows :

Component	*mass %*
Nitric Acid	15
Sec-Butyl phenol	65
4, 6 Dinitro-o-sec-butyl phenol	18
3, 6 Dinitro-p-sec-butyl phenol	2

Calculate :

(a) Conversion

(b) Yield of ortho and para products.

(c) (1) Discuss methods of solving material balance problems without chemical reaction.

(2) Discuss the importance of recycling and by passing operation.

4 (a) Answer the following questions briefly : **4×1=4**

(1) State the first law of thermodynamics.

(2) Write Bernoullie equation.

(3) Define : Net calorific value of fuel.

(4) Enumerate the applications of Hess's law of heat summation.

(b) Answer the followings : **2×3=6**

(1) The gross calorific value of gaseous propane is 2219.7 kJ/mol at 298 K. Calculate its net calorific value if the latent heat of vaporization of water is 2442.5 kJ/kg at this temperature.

(2) What is fuel ? Classify it with examples.

(c) Solve the followings : **2×5=10**

(1) Calculate standard heat of reaction at 298 K when gaseous ammonia is dissolved in water to form 2% (by weight) solution of ammonia. The standard heat of formation of ammonia, water and ammonia hydroxide are –45.94 kJ/mol; –285.83 kJ/mol; –361.20 kJ/mol respectively.

(2) Temperature of 1 ml. of oxygen is raised from 350 K to 1500 K. Calculate heat required using $C_p^{(0)}$ data.

$$C_p^{(0)} = a + bT + cT^2 + dT^3 \ (kJ/kmol\,K)$$

where $a = 26.0257$

$b = 11.7551 \times 10^{-3}$

$c = -2.3426 \times 10^{-6}$

$d = -0.5623 \times 10^{-9}$

5 Attempt any **two** : **2×7=14**

(a) A heat exchanger for cooling a hot hydrocarbon liquid uses 10,000 kg/hr of the cooling water. The hydrocarbon liquid enters the exchanger at 423 K and leaves at 338 K at the rate of 5000 kg/hr. Cooling water is available at 294 K. Calculate the outlet temperature of water.

Data :

heat capacity of hydrocarbon oil = 2.57 kJ/kgK

heat capacity of water = 4.186 kJ/kgK

(b) A mixture of aniline and water containing 11.8% (by weight) aniline is subcooled into the overhead condenser of a distillation column from 373 K to 313 K with the help of cooling water at the rate of 8000 kg mixture per hr. Find the heat removed per hour in the condenser.

Heat capacity data :

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

Compound	a	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$
Aniline	206.27	−211.5065	564.2902	0
Water	50.845	213.08	−631.398	648.746

→ Molecular weight of aniline is 93.12 kg/kmol

→ Molecular weight of water is 18 kg/kmol.

(c) Flue gases from a boiler-chimney has following composition. Assume complete combustion of fuel.

Species	Composition by volume (%)
CO_2	11.4%
N_2	84.4%
O_2	4.2%

(1) Calculate % excess air used for the combustion.

(2) Find C/H ratio of fuel.

6 Attempt any **two** : **2×8=16**

(a) A sample of coal is found to have 65% carbon and 12.7% ash by weight. The refuse obtained after burning fuel has 8.6% carbon. Assume that negligible oxygen is present in the coal. Flue gas analysis shows the following compositions by volume.

GAS	Composition by volume (%)
CO_2	10.6%
O_2	8.7%
N_2	80.7%

(1) Calculate actual weight of dry air used to burn the coal.

(2) Weight of flue gases produced by burning the coal.

(b) Evaluate heat of reaction for : $SO_2 + \frac{1}{2}O_2 \rightarrow SO_3$ occurring at 1 atm pressure and 775 K. The heat capacity follows $C_P^{(0)} = a + bT + cT^2 + dT^3$ in kJ/kmol K. Heat of reaction at 298 K is – 98910 kJ/kmol of SO_2 used up of SO_2 used up.

Data :

Species	a	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$
SO_2	24.771	62.9481	–44.2582	11.122
O_2	26.0257	11.7551	–2.3420	–0.5623
SO_3	22.0376	121.624	–91.8673	24.3691

(c) Napthalene is evaporated in a jacketed vessel. Napthalene is fed to the vessel at 303 K and is vaporized at atmospheric pressure by condensing the eutectic mixture of diphenyl - diphenyl oxide vapours in the jacket at 171 KPa a. Assume no subcooling of vapours. Calculate the quantity of eutectic mixture condensed per 100 kg of naphthalene evaporated.

Data on Naphthalene :

Melting Point	Boiling Point	Latent heat of fusion	Latent of vaporization
353.2 K	491 K	150.7 kJ/kg	316.1 kJ/kg

→ Heat capacity of solid naphthalene in kJ/kgK
= – 0.092 + 0.0046 T

→ Heat capacity of liquid naphthalene in kJ/kgK
= 0.57015 + 0.0033 T

Data on Eutectic mixture

→ Latent heat of vaporization = 291.77 kJ/kg.