liquor. The crystals are then dried to zero free water ($CuSO_4 \cdot 5H_2O$). The allowable impurity in the product is 0.6 per cent. Calculate

(a) the weight of water and of recycled mother liquor required per 100 lb of impure copper sulfate.

(b) the percentage recovery of copper sulfate assuming that the mother liquor not recycled is discarded.

Given : The solubility of $CuSO_4 \cdot 5H_2O$ at 80°C is 120 g per 100 g of free H_2O and at 25°C is 40 g per 100 g of free H_2O. 5+5

8. (a) Write a short note on the idealized crystallizer model, Mixed – suspension-mixed-product-removal (MSMPR).

(b) Develop the model equations for a continuous steady state single stage liquid-liquid extraction process.

(c) Write a short note on Freundlich isotherm with its application to design the stage operation. 3+4+3

Sixth Semester Examination – 2010

MASS TRANSFER – II

Full Marks – 70

Time : 3 Hours

*Answer Question No. **1** which is compulsory and any **five** from the rest.*

The figures in the right-hand margin indicate marks.

1. Answer the following questions : 2×10

(a) Define selectivity, distribution coefficient, and recoverability while choosing a solvent in liquid-liquid extraction process.

(b) Write a short note on fractional extraction process used for the separation of two solutes.

(c) Draw the flow sheet of three-stage counter current mixer-settler extraction cascade process.

(d) Write a short note on Adsorption Hysteresis.

(e) Write a short note on heat of adsorption.

(f) Discuss the effect of temperature and pressure on adsorption process.

(g) Discuss the breakthrough curve.

(h) Write a short note on the mechanism of batch drying process.

(i) Discuss, in short, different types of leaching process.

(j) Write a short note on draft-tube-baffle crystallizer.

2. The equilibrium adsorption of benzene vapor from a mixture of benzene vapor and nitrogen on a certain activated charcoal at 33.3°C is reported as follows :

Benzene vapor adsorbed, cm^3 (STP)/g charcoal	65	80	90	100
Partial pressure benzene, mm Hg	0.251	1.00	2.81	7.82

(a) Define "phase E" and "phase R" for this system.

(b) Plot equilibrium data as X=g mole benzene/kg charcoal and Y = g mole benzene/kg mole nitrogen.

(c) A nitrogen-benzene vapor mixture containing 1.0% benzene by volume is to be passed counter-currently at the rate 4.72×10^{-2} m^3/s to a moving stream of activated charcoal so as to remove 90% of the benzene from the gas in a continuous process. The entering charcoal contains 65 cm^3 benzene vapor (at STP) adsorbed per gram charcoal. The temperature and total pressure are to be maintained at 33.3°C and 1 std. atm, respectively, throughout. Nitrogen is not adsorbed. What is the minimum amount of charcoal which can be used per second ?

(d) If charcoal used is twice as that of the minimum amount, what will be the

concentration of benzene adsorbed upon the charcoal leaving ? To how many equilibrium stages will the process be equivalent ? 2+3+3+2

3. Roasted copper ore containing copper as $CuSO_4$ is to be extracted in a counter current extractor. The feed charge to be treated per hour comprises 10 tons of gangue, 1.2 tons of $CuSO_4$ and 0.5 ton of water. The strong solution produced is to consist of 95% water and 5% $CuSO_4$ by weight. The recovery of $CuSO_4$ is to be 90% of that in the ore. Pure water is to be used as the fresh solvent. After each stage, one ton of inert gangue retains 2 tons of water plus the copper sulphate dissolved in that water. How many equilibrium stages are required? Assume no solid is lost in the overflow so that the rate of gangue remains constant in all the stages. 10

4. A stream of waste water containing 2% benzoic acid is to be extracted with benzene at a rate of 2000 kg/h in order to remove 98% of the solute. If water and benzene are assumed to

be mutually insoluble and the distribution coefficient is $K = x/y^* = 1.707$ at the given temperature (where x and y are mass fractions of the solute in water and benzene phases respectively), calculate

(a) the minimum rate of benzene required for countercurrent separation of the mixture,

(b) the number of stages required if 1.3 times the minimum solvent is used, and

(c) the total amount of solvent required for the separation in a four-stage cross-current device if the same amount of solvent is fed to each stage. 4+3+3

5. A laboratory drying test was made on a 0.1 m^2 sample of a fibrous board like material. The sample was suspended from a balance, its edges were sealed, and drying took place from the two large faces. The air had a dry-bulb temperature of 65°C, wet-bulb temperature 29°C, its velocity was 1.5 m/s past the sample.

The following are the weights recorded at various times during the test :

Time, h	Mass, kg	Time, h	Mass, kg	Time, h	Mass, kg
0	4.820	3.0	4.269	7.0	3.885
0.1	4.807	3.4	4.206	7.5	3.871
0.2	4.785	3.8	4.150	8.0	3.859
0.4	4.749	4.2	4.130	9.0	3.842
0.8	4.674	4.6	4.057	10.0	3.832
1.0	4.638	5.0	4.015	11.0	3.825
1.4	4.565	5.4	3.979	12.0	3.821
1.8	4.491	5.8	3.946	14.0	3.81[illegible]
2.2	4.416	6.0	3.933	16.0	3.819
2.6	4.341	6.5	3.905		

The sample was then dried in an oven at 110°C, and the dry mass was 3.765 kg.

(a) Plot the rate-of-drying curve.

(b) Estimate the time required for drying the same sheets from 20 to 2% moisture (wet basis) using air of the same temperature and humidity but with 50% greater air velocity. Assume that the critical moisture remains unchanged. 4+6

6. A mineral containing 20% elemental sulfur is to be leached with hot gas oil, in which the sulfur is soluble to the extent of 10% by weight. The solvent will be repeatedly pumped over the batch of ground mineral, using 1.5 kg fresh solvent per kg mineral. After no further solution of sulfur is obtained, the liquid will be drained and replaced with a fresh batch of 1.5 kg oil per kg original mineral, and the operation repeated. On drainage, the solid materials retain the solution to the extent of one-tenth the weight of undissolved solid (sulfur and gangue). No preferential adsorption takes place.

(a) Calculate the equilibrium data and plot them in usual manner.

(b) Determine the amount of sulfur unextracted and the sulfur concentration of the composited leach liquors. 5+5

7. $CuSO_4.H_2O$ containing 3.5 per cent of a soluble impurity is dissolved continuously in sufficient water and recycled mother liquor to make a saturated solution at 80°C. The solution is then cooled to 25°C and crystals of $CuSO_4.5H_2O$ thereby obtained. These crystals carry 10 per-cent of their dry weight as adhering mother