**Time: 3 Hours** **Marks: 80**

**N.B 1.Question number one is compulsory.**
**2.Attempt any three of the remaining questions.**
**3.Each question carries equal marks.**
**4. Figures to the right indicate marks.**
**5. Make suitable assumptions when required.**

**1** **(a)** Define the following:- Normality, specific gravity,adiabatic flame temperature,percentage excess and selectivity in chemical reaction **10**

**(b)** 2000 ml solution of strength 0.5 N $H_2SO_4$ is to be prepared in laboratory by adding 98% $H_2SO_4$(sp.gr.1.84) to water. Calculate the volume in mL of 98% $H_2SO_4$ to be added to the solution of required strength. **10**

**2** **(a)** Fresh juice contains 15% solids and 85% water by weight and is to be concentrated to contain 40% solids by weight.In single evaporation system, it is found that volatile constituents of juice escape with water leaving the concentrated juice with a flat taste. In order to overcome this problem, part of the fresh juice bypasses the evaporator.Calculate: **10**

(a) The fraction of juices that bypasses the evaporator.
(b) The concentrated juice produced (containing 40% solids) per 100kg of fresh juice fed to the process.

**(b)** 2000 kg of wet solids 70% solids by weight are fed to a tray of water where it is dried by hot air. The product finally obtained is found to contain 1% moist weight , calculate : **10**

(a) The kg of water removed from wet solids.
(b) The kg of product obtained.

**3** Monochloracetic acid ($CH_2$ClCOOH) is manufactured in a semi batch reactor by the action of glacial acetic acid ($CH_3$COOH) with chlorine ($Cl_2$) gas using a suitable catalyst at 373K($100^0$C). **20**

The reaction is $CH_3COOH + Cl_2 \rightarrow CH_2ClCOOH + HCl$

The chlorine used 15% (mole) in excess of that theoretically required. The reaction is 95% complete. During chlorination the liberated hydrochloric acid gas is scrubbed with water in order to obtain 20% (weight) hydrochloric acid solution. Calculate : (a) the raw materials required for 3000kg of monochloroacetic acid production per batch and (b) the amount of 20% (weight) HCl solution produced per batch.

**4** **(a)** A gas mixture containing 15 mole % 'A' and 85 mole % insert's is fed to an absorption tower where it is contacted with liquid solvent 'B' which absorbs 'A'. The mole ratio of solvent to gas entering the tower is 2:1. The gas leaving the absorber contains 2.5% 'A', 1.5% 'B' and rest inerts on mole basis.Calculate: **10**

(i) The percentage recovery of solute 'A'
(ii) The fraction of solvent 'B' fed to the tower lost in gas leaving the column (during the process some solvent evaporates and gets added in gas leaving the column).

**(b)** Draw the neat diagram of the following operations and write their respective material balance equations. Specify if there is a tie component in the operation. **10**
(i)Distillation (ii) Absorption (iii) Crystallization (iv)Extraction (v)Extraction

**5** **(a)** In a laboratory, a steam boiler is fired with liquefied petroleum gas ( it may be treated as pure n-butane ). 100% excess air is used. The fuel and air enter the combustion chamber at 298 K. The flue gases leave the boiler at 523K. Determine the amount of energy transferred as heat in the boiler for 15 kg fuel. Assume complete combustion and insulating boiler**.** **20**

(i) The standard heat of combustion (net heating value) of n-butane is -2635.58 kJ/mol
(ii) The constants in the heat capacity equation are as given below

$c^0_p$ = a + bT + $eT^{-2}$ , kJ/kmol.K)

| component | a | b×$10^3$ | e×$10^{-5}$ |
|---|---|---|---|
| $CO_2$ | 45.369 | 8.688 | -9.619 |
| $O_2$ | 30.255 | 4.207 | -1.887 |
| $H_2O$ (g) | 28.850 | 12.055 | -1.066 |
| $N_2$ | 27.270 | 4.930 | 0.333 |

**6** **a)** Carbon monoxide at 1000 K is burned with air at 800 K. 90% excess air is used. The products of combustion leaves the reaction chamber at 1250 K. The standard heat of reaction at298K is -283.028kJ/mol CO burned. The mean specific heats applicable in the temperature range for the reaction conditions for CO,$CO_2$,$O_2$ and $N_2$ are 29.38,49.91,33.13 and 31.43 (J/mol K) respectively. Calculate the heat evolved in the reaction chamber per kmol of CO burned. **10**

**b)** Give the step wise procedure to calculate the reboiler load in a distillation unit. List the parameters required for the computation of the above. **10**

**********