(1) Question No. **1** is **compulsory**.
(2) Attempt any **four** questions from remaining **six** questions.
(3) Assume **suitable** data wherever **necessary**.
(4) **Figures** to the **right** indicates **full** marks.

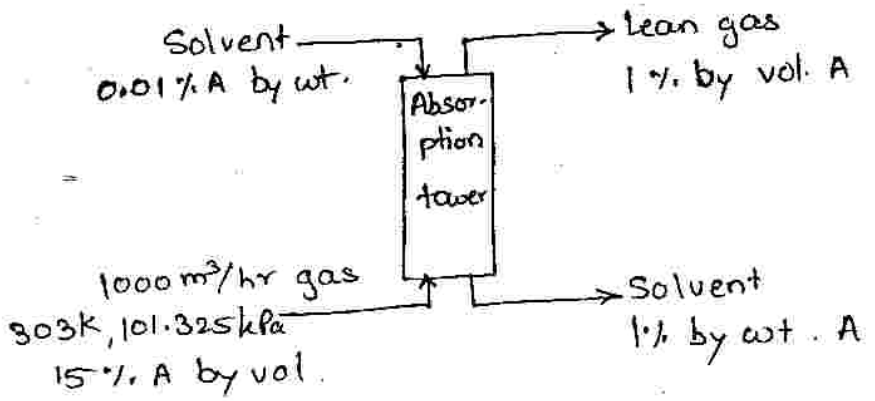
) A sample of wine contains 20% alcohol (ethanol) on volume basis. Find the weight % of alcohol in the wine. Assume densities of alcohol and alcohol free liquid (water) to be 0·79 kg/*l* and 1 kg/*l* respectively. **5**

) The feed to a fractionating column analyses by weight as 28% Benzene and 72% Toluene. The analysis of distillate shows 52% Benzene and 5% Benzene was found to be bottom product per 1000 kg of feed/hr. Calculate % recovery of Benzene and also find amount of distillate and bottom product. **7**

c) A solution of caustic soda contains 20% NaOH by weight. The density of solution is 1·196 kg/lit. Find normality and molarity of the solution. **4**

d) The analysis of the gas sample is given below CH_4 = 60%, CO_2 = 30%, NH_3 = 10% Find the average molecular weight of the gas. **4**

a) Absorption system utilized for absorption of solute gas **A** (molecular weight 64) is shown. **10**



Calculate the mass flow rate of solvent to tower.

(b) Slabs of building boards contain 16% moisture . They are dried to a water content of 0·5% by circulating hot air over them. The outgoing air contains 0·09 kg water vapour per kg dry air. Calculate the quantity of fresh air required per 1000 kg/hr net dry board, if the fresh air is supplied at 301 K and 101·325 kPa containing 0·02 kg/kg dry air humidity. **10**

20

CH_4 reacts with Cl_2 to produce methyl chloride and HCl

$$CH_4 + Cl_2 \longrightarrow CH_3Cl + HCl.$$

Once formed CH_3Cl may undergo further chlorination to form CH_2Cl_2 and $CHCl_3$ and CCl_4 In CH_3Cl production process CH_4 and Cl_2 are fed to a reactor in a mole ratio 5 : 1. A single pass Cl_2 conversion of 100% may be assumed. The mole ratio of CH_3Cl and Cl_2Cl_2 in the product is 4 and negligible amount of $CHCl_3$ and CCl_4 are produced. The product gases are cooled to condense CH_3Cl and CH_2Cl_2 which are then separated in a distillation column. The gas leaving the condenser goes to a scrubber in which HCl is absorbed. The gas leaving the scrubber which may be considered as pure methane, is recycled back to reactor for production rate of 1500 kg/hr of CH_3Cl. Calculate–

(i) The flow rate and molar composition of the fresh feed
(ii) The molar flow rate of recycle stream
(iii) The rate at which HCl must be removed in a scrubber
(iv) The combined feed ratio
(v) Recycled rated based on CH_4.

[TURN OVER

4. (a) A dryer is used to dry season wood and evaporates 27 kg/hr of water from freshly cut green wood. Air enters the dryer at 40% relative humidity and at 47°C. It leaves the dryer at 80% relative humidity at 37°C. If the entire process operates at 100 kPa, how many m^3/hr of moist air enters the dryer.

Vap. press of water at 37°C = 6·274 kPa

Vap. press of water at 47°C = 10·612 kPa

(b) A gaseous reaction $A \longrightarrow 2B + C$ takes place isothermally in a constant pressure reactor. Starting with, a mixture of 75% A and 25% inerts (by volume). In a specified time the volume doubles. Calculate conversion achieved.

5. (a) A tank of 2000 kg capacity contains 800 kg water initially. A 50% w/w solution of a chemical x in water is added at the rate of 200 kg/hr. The solution in tank is well mixed such that the composition of solution in tank and its outlet is same. The mixed solution is also continuously withdraw at a rate of 100 kg/hr. from tank. Find the composition of chemical X in solution when liquid level in tank reaches 2000 kg limit. Find the time required for this.

(b) The gross calorific value of gaseous n-butane is 2877·40 kJ/mol at 298 k. Calculate its net calorific value in kJ/mol and kJ/kg.
Latent heat of water vapour at 298 k is 2442·5 kJ/kg.

6. (a) Calculate the standard heat of formation of n-propanol liquid using following data–

Std heat of formation of $CO_2(g)$ = – 393·51 kJ/mol

Std. heat of formation of H_2O (l) = – 285·83 kJ/mol

Std. heat of combustion of n-propanol = – 2028·19 kJ/mol

(b) Calculate the theoretical flame temperature of a gas containing 20% CO and 80% Ne when burnt with 150% excess air, both air and gas being at 25°C.
Data : Heat of formation in cal/g mol at 25°C of CO_2 = – 94052, CO = – 26412. Specific heat in cal/g mol °K of CO_2 = 12·1, O_2 = 7·90 N_2 = 7·55.

7. (a) The following enthalpy changes are known from experiment for the reactions given below at 25°C std. State. Calculate the standard heat of formation of propylene gas

	Reactions	**ΔH (kcal/g mol)**
(i)	$C_3H_6(g) + H_2(g) \rightarrow C_3H_8(g)$	29·60
(ii)	$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$	530·90
(iii)	$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$	68·30
(iv)	$C(s) + O_2(g) \rightarrow CO_2(g)$	94·05

(b) Methane is oxidised with air to produce formaldehyde as for the following equation

$$CH_4(g) + O_2(g) \rightarrow HCHO(g) + H_2O(g)$$

$$\Delta H_R^\circ = -283{\cdot}094 \text{ kJ/mol.}$$

100 mole of methane are fed to the rector at 311 k, air is used 50% excess and supplied at 373 k. If the percent conversion is 60%, Calculate the heat that must be removed for the product stream to emerge at 478 K.
Data : C°pm for air (373 – 298) K = 29·2908 kJ/k mol °K

Component	**C°pm (311 – 298)**	**C°pm (478 – 298)**
CH_4	36·044	40·193
N_2	—	29·286
O_2	—	30·082
HCHO	—	41·2902
H_2O	—	34·239