Name: Enrolment No:	

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End semester Examination, December 2023

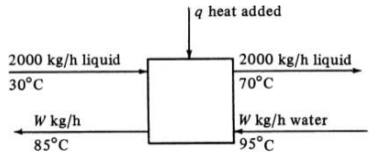
Programme Name: B. Tech. (CERP) **Semester : III**
Course Name : Material and Energy Balance Computations **Time : 3 hrs**
Course Code : CHCE 2025 **Max. Marks : 100**
Nos. of page(s) : 02
Instructions : Assume any missing data. Draw the diagrams, wherever necessary.

SECTION A
(5X4=20 marks)

S. No.		Marks	CO
1	A flue gas analyzes H_2=22 Cl_2 = 14 % CO = 51% and O_2 = 13% by volume. Find (i) Composition of the gas mixture by weight % (ii) Density of the gas mixture in lb/ft^3 at 180^{O}F & 760 mm Hg.	4	CO1
2	A mixture of acetone vapor and nitrogen gas at atmospheric pressure and 295K contains acetone vapor to the extent that it exerts a partial pressure of 15 kPa. The vapor pressure of acetone at 295K is 26.36 kPa. **Solve** for 1) Molal saturation 2) Absolute saturation 3) Relative saturation 4) % relative saturation	4	CO2
3	The Orsat analysis of the flue gases from a boiler house chimney gives CO_2:11.4%, O_2:4.2% and N_2:84.4% (mole%). If complete combustion has taken place, (a) **Calculate** the % excess air, and (b) find the C:H ratio in the fuel.	4	CO2
4	Aluminum reacts with chlorine gas to form aluminum chloride via the following reaction: 2Al + 3Cl_2 ---> 2$AlCl_3$. If 34 g of aluminum and 39 g of chlorine gas are used. F**ind** limiting reactant and calculate %excess reactant.	4	CO3
5	The heat capacity of silicon carbide is given by Cp=37.221+1.22x10^{-2} T-1.189x10^5 T^{-2} where Cp is in KJ/kmol K and T is in K. **Estimate** the enthalpy change in silicon carbide in the range 0 to 1000 K.	4	CO4

SECTION B
(4 X 10=40 marks)

6	Power required in an agitator is a function of rotational speed (n), impeller diameter (d), fluid properties like density(ρ), viscosity (μ), and acceleration due to gravity (g). **Recognize** a relation between the dimensionless groups using dimensional analysis.	**10**	**CO1**
7	A 10.20 g sample of a gas has a volume of 5.25 L at 23 °C and 751 mmHg. If 2.30 g of the same gas is added to this constant 5.25 L volume and the temperature raised to 67 °C, **what** is the new gas pressure?	**10**	**CO2**
8	The solubility of barium nitrate [$Ba(NO_3)_2$] in water at 373 and 273K are 34 g [$Ba(NO_3)_2$]/100 g water and 5 g [$Ba(NO_3)_2$]/100 g water, respectively. If the saturated solution at 373 K is cooled to 273 K, if 200 g of crystals precipitate out, **what** is the weight of the initial solution at 373K. Molar mass of barium = 137 g/mol.	**10**	**CO3**

<table>
<tr>
<td>9</td>
<td>A liquid fermentation medium at 30°C is pumped at a rate of 2000 kg/h through a heater, where it is heated to 70°C under pressure. The waste heat water used to heat this medium enters at 95°C and leaves at 85°C. The average heat capacity of the fermentation medium is 4.06 kJ/kg · K, and that for water is 4.21 kJ/kg · K. The fermentation stream and the wastewater stream are separated by a metal surface through which heat is transferred and the streams do not physically mix with each other as shown in figure below.


Calculate the water flow rate required and the amount of heat added to the fermentation medium assuming no heat losses.</td>
<td>10</td>
<td>CO4</td>
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<tr>
<td colspan="4">SECTION C
(2 X 20=40 marks)</td>
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<td>10</td>
<td>In anaerobic digestion of grain, the yeast saccharonnyces cerevisiae digests glucose from plants to form products ethanol and propionic acid according to
Reaction 1: $C_6H_{12}O_6$ --------→ $2C_2H_5OH + CO_2$
Reaction 2: $C_6H_{12}O_6$ --------→ $2C_2H_3CO_2H + 2H_2O$
In a batch process, 4000 Kg of a 12% glucose/water solution is charged, and after fermentation 120 Kg of carbon dioxide is produced leaving 90 kg of glucose unreacted. Compute the weight percent of ethyl alcohol and propionic acid remaining in the broth.</td>
<td>20</td>
<td>CO3</td>
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<td>11</td>
<td>One kg of water is heated from 250 K to 400 K at one standard atmospheric pressure. Estimate, how much heat is required for this?
Data: The mean heat capacity of ice Cp=2.03 KJ/kmol K (between 250 and 273 K)
The heat capacity of water between 273 K and 373 K is 1 btu/lb °F.
The heat capacity of water vapor from 373 to 400 K is
$Cp=30.475+9.652x10^{-3} T + 1.189x10^{-6} T^2$.
The latent heat of fusion of water is 144 btu/lb and that of vaporization is 40608 KJ/Kmol.
OR
The heat capacity of benzene at two different temperatures is
<table>
<tr><td>T (K)</td><td>293</td><td>323</td></tr>
<tr><td>Cp (J/gmol K)</td><td>131.05</td><td>138.04</td></tr>
</table>
Fit the data into an equation of the form Cp=a+bT.
Calcualte the heat required to convert 100 kg of liquid benzene from 293.15 K to saturated vapor at the boiling point of 353.25 K. The latent heat of vaporization may be calculated using the Kistyakowsky equation $\frac{\Delta H}{T_b} = 36.63 + 8.31\, lnT_b$ where Tb is the boiling point of benzene and ΔH is the heat of vaporization.</td>
<td>20</td>
<td>CO4</td>
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