Name:

Enrolment No:

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

Supplementary Examination, December 2023

Programme Name: B. Tech. (CERP) **Semester : III**
Course Name : Material and Energy Balance Computations **Time : 3 hrs**
Course Code : CHCE 2013 **Max. Marks : 100**
Nos. of page(s) : 02
Instructions : Assume any missing data. Draw the diagrams, wherever necessary.

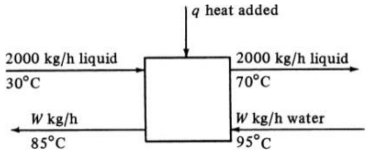
SECTION A
(5X4=20 marks)

S. No.		Marks	CO
1	A mixture of gases has the following composition by weight N_2=34 Cl_2 = 22 % Br_2 = 25% and O_2 = 19%. **Find** (i) Composition of the gas mixture by volume % (ii) Density of the gas mixture in kg/m3 at 25^{O}C & 740 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 % relative saturation	**4**	**CO2**
3	10 kg of CH_4 is burnt with 10% excess air. **What** will be the volume of the air used for combustion if air is at 30°C and 1.3 atm pressure?	**4**	**CO3**
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. **Find** limiting reactant and calculate %excess reactant.	**4**	**CO4**
5	The heat capacity of silicon carbide is given by $C_P = 37.221 + 1.22X10^{-3}T - 1.189X10^5T^{-2}$ 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**	**CO5**

SECTION B
(4 X 10=40 marks)

6	A gas containing only CH_4 and N_2 is burned with air yielding a flue gas that has an Orsat analysis of CO_2: 8.7%, CO: 1.0%, O_2: 3.8%, and N_2: 86.5%. **Infer** the percent excess air used in combustion and the composition of the CH_4 and N_2 mixture.	**10**	**CO3**
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**	**CO4**
8	A solution of sodium chloride is available at 343 K which is saturated. This solution when cooled to 298 K, releases 100 g of crystals of NaCl. **Estimate** the weight of the initial solution at 343K. The solubility of NaCl in water at 343 and 298 K are 6.39 and 6.14 kmol /1000 kg water respectively.	**10**	**CO5**
9	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	**10**	**CO6**

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.

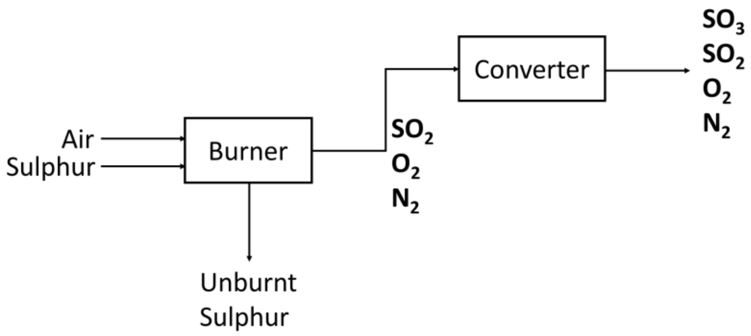


Calculate the water flow rate required and the amount of heat added to the fermentation medium assuming no heat losses.

SECTION C
(2 X 20=40 marks)

10

A simplified process for SO_2 to SO_3 is as shown in the figure below.



Sulfur is burned with 100% excess air in the burner though the conversion of SO_2 is only 90%. In the converter, the conversion from SO_2 to SO_3 is only 95%. ***Calculate*** the lbs of air needed to burn 100 lbs of Sulfur and the composition of exiting stream from the converter.

20 **CO4**

11

A natural gas stream has the following composition on mole basis:
CH_4 – 84%, C_2H_6 – 13% and N_2 – 3%.
Analyze the heat to be added to heat 10 kmol of natural gas from 298 K to 523 K using the heat capacity data given below.

$$C_P = a + bT + cT^2 + dT^{-2}, \text{ kJ/ (kmol-K)}.$$

Gas	a	b x 10^3	c x 10^6	d x 10^9
CH_4	19.2494	52.1135	11.973	-11.3173
C_2H_6	5.4129	178.0872	-67.3749	8.7147
N_2	29.5909	-5.141	13.1829	-4.968

OR

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
$Cp=30.475+9.652\times10^{-3} T + 1.189\times10^{-6} T^2$.
The latent heat of fusion of water is 144 btu/lb and that of vaporization is 40608 KJ/Kmol.

20 **CO6**