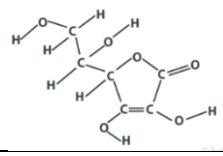
Name: **Enrolment No:**	UPES UNIVERSITY OF TOMORROW

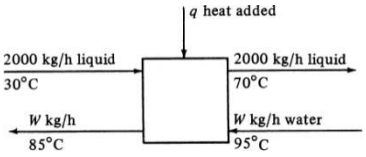
UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End semester Examination, Dec 2023

Programme Name: B. Tech. (Biotech) **Semester : III**
Course Name : Process Calculations **Time : 3 hrs**
Course Code : HSBT2003 **Max. Marks : 100**
Nos. of page(s) : 03
Instructions : Assume any missing data. Draw the diagrams, wherever necessary.

SECTION-A (20 Q× 1.5M = 30 marks)
(Answer all the questions)

		Marks	CO
1	What is the equivalent temperature of 933^{o}R in ^{o}C , ^{o}F and K.	**1.5**	**CO1**
2	If your automobile tire takes a pressure of 35 psig, what is the equivalent pressure in atmospheric and Kpa?	**1.5**	**CO1**
3	The molecular formula of oscarbic acid is as shown below. How many gmol of this compound contained in 20 grams? 	**1.5**	**CO1**
4	$CaCO_3$-----→ CaO +CO_2. How many Kgs of carbon dioxide is produced when we burn 100 kg limestone.	**1.5**	**CO1**
5	A water-soaked cloth is dried from 32 to 5%. Find the weight of the water removed from 82 kg of wet cloth.	**1.5**	**CO1**
6	Mass that a cube contains is 40 gm and has side length of 1 cm. What is the density of the material inside the cube in kg/m^3?	**1.5**	**CO1**
7	What is the molar flow rate of sodium solution (pure) if 80 gms of solution is collected in 20 seconds.	**1.5**	**CO1**
8	What is the percent by weight of C in CO_2?	**1.5**	**CO1**
9	In 13 kg water, how many lb moles of water are present?	**1.5**	**CO1**
10	What is the weight fraction of N2 in a mixture of N_2 and CO_2 with a mole ratio 1:2.	**1.5**	**CO1**
11	What is latent heat of condensation?	**1.5**	**CO1**
12	Convert 15 Btu/hr.ft2 °F to cal/s.cm2 °C.	**1.5**	**CO2**
13	What is the volume of 25 kg of chlorine gas at NTP?	**1.5**	**CO2**
14	Convert 5 cal/gm °C to kJ/g °C and 875°F to Kelvin.	**1.5**	**CO2**
15	State ideal gas law.	**1.5**	**CO2**
16	Convert 499 g of $CuSO_4.5H_2O$ into moles.	**1.5**	**CO2**
17	What is limiting reactant?	**1.5**	**CO2**

18	What is steady state? Explain.	**1.5**	**CO2**
19	Explain Dalton's law.	**1.5**	**CO2**
20	Define selectivity	**1.5**	**CO2**
	SECTION-B (4 Q× 5M = 20 marks) **(Answer all the questions)**		
21	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.	**5**	**CO1**
22	Aluminum reacts with chlorine gas to form aluminum chloride via the following reaction: $2Al + 3Cl_2$ ---> $2AlCl_3$. If 34 g of aluminum and 39 g of chlorine gas are used find limiting reactant and calculate %excess reactant.	**5**	**CO2**
23	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%). Assuming that complete combustion has taken place, (a) Calculate the % excess air, and (b) find the C:H ratio in the fuel.	**5**	**CO3**
24	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.	**5**	**CO4**
	SECTION-C (2 Q× 10M = 20 marks) **(Answer all the questions)**		
25	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, a) if 200 g of crystals precipitate out, what is the weight of the initial solution at 373K. b) What is the composition of the residual liquid. Molar mass of barium = 137 g/mol.	**10**	**CO2**
26	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.  A) What are the relevant assumption and formulae used? B) Calculate the water flow rate required and the amount of heat added to the fermentation medium assuming no heat losses.	**10**	**CO4**

T SECTION-D (2 Q× 15M = 30 marks)
(Answer all the questions)

27 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.

a) What are the weight percent of ethyl alcohol remaining in the broth
b) What are the weight percent of propionic acid remaining in the broth.

15 **CO2**

28 Solid municipal gas can be burned into gas with the resulting composition of 9.2% CO_2, 1.5% CO, 7.3% O_2 and 82% N_2. By neglecting the presence of water vapor in the gas,

a) What is the average heat capacity of the gas between 200^0F and 500^0F
b) Evaluate the enthalpy difference for lbmol of the gas between 200^0F and 500^0F

The heat capacity equation is $C_p = A + B\,T - C\,T^2 + D\,T^3$ where C_p is in Btu/lbmol ^{0}F and T in ^{0}F. The values of constants are as given in the table.

Component	A	B	C	D
CO_2	6.895	0.7624×10^{-3}	0.7009×10^{-7}	
CO	7.104	0.7851×10^{-3}	0.5528×10^{-7}	
O_2	8.448	5.757×10^{-3}	21.59×10^{-7}	3.059×10^{-10}
N_2	6.865	0.8024×10^{-3}	0.7367×10^{-7}	

15 **CO4**