P P SAVANI UNIVERSITY

Third Semester of B. Tech. Examination

December 2021

SECH2010 CHEMICAL PROCESS CALCULATION

07.12.2021, Tuesday | Time: 09:00 a.m. To 11:30 a.m. | Maximum Marks: 60

Instructions:

1. The question paper comprises of two sections.
2. Section I and II must be attempted in separate answer sheets.
3. Make suitable assumptions and draw neat figures wherever required.
4. Use of scientific calculator is allowed.
5. Atomic Weight **O :16, C:12,K:39,H:1,N:14,S:32,Zn:65.4,Cl:35.5,Cu:63.5,Ca:40,Fe:56,Na:23**

SECTION – I

Q - 1	Answer the Following: (Any Five)	[05]
(i)	Name the two types of process flow diagram.	
(ii)	Define density of gas mixture.	
(iii)	Define Ideal Gas Law.	
(iv)	Convert: 1 Atmospheric pressure = ...Psi.	
(v)	Define Steady state process.	
(vi)	Define selectivity.	
(vii)	Define Vapor pressure.	
Q - 2 (a)	Define: (i) Molarity (ii)Molality (iii)Normality	[05]
Q - 2 (b)	The analysis of a sample of glass yields 7.8% Na_2O, 7.0% MgO, 9.7% ZnO, 2.0% Al_2O_3, 8.5% B_2O_3 and 65% SiO_2 (by weight). Convert this composition into mole%	[05]
	OR	
Q - 2 (a)	The effective heat capacity of mixture of gases is given by $C_P = 7.13 + 0.577 \times 10^{-3} t + 0.0284 \times 10^{-6} t^2$ Where CP is in Btu/(lb-mol°F) and t is in °F. Determine the units of the constants in the above equation. Change the equation into the form in which CP is given in kJ/(kmol K) and temperature is in K	[05]
Q - 2 (b)	The weight of an object is 300 N at a location where acceleration due to gravity is 9.81 m/s². (a) Determine the mass of the object in kilograms. (b) Express the mass in the FPS system.	[05]
Q - 3 (a)	The Orsat analysis of the flue gases from a boiler house chimney by volume is given below: CO_2: 11.4%, O_2: 4.2% and N_2: 84.4%, assuming that complete combustion takes place, 1. Calculate the % excess air 2. Find the C:H ration in the fuel	[05]
Q - 3 (b)	A coal sample gave the following analysis of weight, Carbon 85%, Hydrogen 6%, and remaining are incombustible items. Determine minimum weight of air required per kg of coal for chemically correct composition.	[05]
	OR	
Q - 3 (a)	The ultimate analysis of a coal sample is given below: C: 61.5%, H_2: 3.5%, S: 0.4%, Ash: 14.2%, N_2:1.8% and rest oxygen. Calculate the following: 1. Theoretical O_2 requirement per unit weight of coal. 2. Theoretical dry air requirement per unit weight of coal	[05]

Q - 3 (b) Equal moles of A and B gas are mixed together in a container at 300 K. The total pressure is found to contain 350 kPa. Determine the partial pressure of gas A. [05]

Data: The M.W. of A and B are 30 and 44 respectively.

Q - 4 Attempt any one. [05]

(i) A slab of building board contains 16% moisture is to be dried to water content of 0.5% by using hot air. The fresh hot air entering dryer contains 0.02 kg water vapour per kg dry air whereas the exhaust air leaving the dryer contains 0.09 kg water vapour per kg dry air. Calculate fresh air required for 1000 kg feed.

(ii) A mixture of $CuSO_4 \cdot 5H_2O$ and $FeSO_4 \cdot 7H_2O$ weights 100 gram. It is heated in an oven at 105 °C to evaporate the water of hydration. Calculate the weight of mixture after removal of water if $CuSO_4$ and $FeSO_4$ are in in equal proportion?

SECTION – II

Q - 1 Answer the Following: (Solve any Five) [05]

(i) % Humidity

(ii) Humid Volume

(iii) Humid Heat

(iv) Antonin Equation

(v) Purge

(vi) Psychometrics Chart

(vii) Bypass

Q - 2 The reaction A = 2B + C takes place in a catalytic reactor (diagram is given below). The reactor effluent is sent to a separator. The overall conversion of A is 95%. The product stream from the separator consists of B, C and 0.5% of A entering the separator, while the recycle stream consists of the remainder of the unreacted A and 1% of B entering the separator. Calculate the [10]

1. single pass conversion of A in the reactor
2. molar ratio of recycle to feed.

OR

Q - 2 (a) Classify the material balance. Discuss the various methods involved for solving material balance problems without chemical reactions. [07]

Q - 2 (b) Explain Dew Point, Wet Bulb Temperature and Dry Bulb Temperature [03]

Q - 3 The analysis of 15000 litre of gas mixture at standard conditions is as follows: [10]

$CO_2 = 9.5\%$; $SO_2 = 0.5\%$; $O_2 = 12.0\%$; $N_2 = 78.0\%$.

How much heat must be added to this gas to change its temperature from 25°C to 700°C?

Data: Specific heat values in kcal/(kmol.K)

Gas	CO_2	SO_2	O_2	N_2
Cp at 25oC	8.884	9.54	7.017	6.961
Cp at 700oC	11.303	11.66	7.706	7.298

OR

Q - 3 Pyrite ore is roasted in chamber plant for making sulphuric acid. The gases leaving the roaster are at 775 K and have molar composition $SO_2 = 7.09\%$, $O_2 = 10.55\%$, $SO_3 = 0.45\%$ and $N_2 = 81.91\%$. Calculate the heat content of 1 kmol gas mixture over 298.15 K by using the given heat capacity data: [10]

Component	a	b x10^3	c x 106	d x 109
SO_2	24.7706	62.9481	-44.2582	11.122
O_2	26.0257	11.7551	-2.3426	-0.5623

SO_3	22.0376	121.624	-91.8673	24.3691
N_2	29.5909	-5.141	13.1829	-4.968

Where, Cp is in KJ/Kmol K and T in K

Q - 4 Attempt any one. **[05]**

(i) The heat capacity of carbon monoxide is given by the following equation.

$Cp = 6.395 + 6.77 \times 10^{-4} T + 1.3 \times 10^{-7} T^2$

where Cp = cal/(gmol)C, T = ^{0}C

What is the enthalpy change associated with heating carbon monoxide from 500 ^{0}C to 1000 ^{0}C?

(ii) Temperature of pure Oxygen is raised from 350 to 1500K. Calculate the amount of heat to be supplied for raising the temperature of 1kmol oxygen using the following Cp_0 data.

$Cp_0 = a + bT + cT^2 + dT^3$ kg/kmol K

a	$bx10^2$	$cx10^6$	$d\ x10^3$
26.0257	11.7551	- 2.3426	-0.5623

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