Q. Code:625074

Reg. No. | | | | | | | | | | | | | |

B.E./ B. TECH.DEGREE EXAMINATIONS, MAY 2024

Third Semester

CH22301 – CHEMICAL PROCESS CALCULATIONS

(Chemical Engineering)

(Regulation 2022)

(USE OF PSYCHROMETRIC CHART IS PERMITTED)

TIME:3 HOURS **MAX. MARKS: 100**

COURSE OUTCOMES	STATEMENT	RBT LEVEL
CO 1	Interpret the data presented in different unit systems and apply various gas laws to calculate the unknowns in a given system	**3**
CO 2	Build basic knowledge on various unit operations and processes and perform material balances for steady and unsteady state chemical systems.	**3**
CO 3	Provide insight into the concepts and calculations associated with gases which involves two phase systems.	**3**
CO 4	Perform energy balance calculations for steady and unsteady state chemical processes.	**4**
CO 5	Implement various methods used for analyzing combustion process and demonstrate the ability to understand process simulators.	**4**

PART- A (20x2=40Marks)

(Answer all Questions)

		CO	RBT LEVEL
1.	Calculate the volume of 15 kg of Chlorine at a pressure of 0.9 bar and 293 K.	**1**	**3**
2.	Differentiate Molarity and Normality.	**1**	**2**
3.	State Dalton's law.	**1**	**2**
4.	Define: Vapour Pressure.	**1**	**2**
5.	Identify the limiting reactant and excess reactant when 12 kg of Carbon reacts with 32 kg of Oxygen to form Carbon-di- Oxide.	**2**	**3**
6.	In an evaporator a dilute solution of 4% NaOH is concentrated to 25% NaOH. Calculate the evaporation of water per kg of feed.	**2**	**3**
7.	SO_2 is produced by the reaction between copper and sulphuric acid. How much Cu must be used to get 10 kg of SO_2?	**2**	**3**
8.	Mention the significance of Recycling operation.	**2**	**2**
9.	Relate absolute humidity and molal humidity.	**3**	**2**
10.	Define: Saturation.	**3**	**2**
11.	Cite the difference between wet bulb temperature and dry bulb temperature.	**3**	**2**
12.	Annotate the significance of psychrometric chart.	**3**	**2**

13.	State Kopp's rule.	**4**	**2**
14.	Differentiate specific heat and latent heat.	**4**	**2**
15.	Write the unsteady state energy balance equation for a batch reactor.	**4**	**2**
16.	Define: Theoretical flame temperature.	**4**	**2**
17.	Relate GCV and NCV.	**5**	**2**
18.	List any two process simulators.	**5**	**2**
19.	Highlight the importance of ultimate analysis.	**5**	**2**
20.	Give the applications of ORSAT analysis.	**5**	**2**

PART- B (5x 10=50Marks)

		Marks	CO	RBT LEVEL
21.(a)	Chimney gas has the following composition: CO_2 : 9.5%, CO : 0.2%, O_2 : 9.6% and N_2 : 80.7%. Using ideal gas law, calculate: (a) its weight percentage (b) volume occupied by 0.5 kg of gas at 30 °C and 760 mm Hg. (c) density of the gas in kg/m^3 at condition of (b) (d) specific gravity of the gas mixture. (Density of air may be taken as 1.3 g/cc)	**(10)**	**1**	**3**
	(OR)			
(b)	A solution of caustic soda in water contains 20% NaOH by weight. The density of the solution is 1196 kg/m^3. Find the molarity, normality and molality of the solution.	**(10)**	**1**	**3**
22.(a)	The waste acid from a nitrating process contains 23% HNO_3; 57% H_2SO_4; 20% water. This acid is to be concentrated to 27% HNO_3, 60% H_2SO_4 by addition of 93% H_2SO_4 and 90% HNO_3. Calculate the weight of acids needed to obtain 1000 kg of desired acid.	**(10)**	**2**	**3**
	(OR)			
(b)	Pure CO_2 may be prepared by treating limestone with sulphuric acid. The limestone used in the process contains $CaCO_3$, $MgCO_3$ and inert compounds. The acid used contains 12% H_2SO_4 by weight. The residue from the process had the following composition: $CaSO_4$: 8.56%, $MgSO_4$: 5.23%, H_2SO_4 : 1.05%, Inert : 0.53%, CO_2 : 0.12%, H_2O : 84.51%. During the process, the	**(10)**	**2**	**3**

mass was warmed where CO_2 and H_2O got removed.

Calculate the following:

(a) The analysis of limestone

(b) The % excess acid used

23.(a)	Air at a temperature of 20°C and pressure 750 mm Hg has a relative humidity of 80%. (a) Calculate the molal humidity of air. (b) Calculate the humidity of this air if its temperature is reduced to 10°C and its pressure increased to 35 psi, condensing out some of the water. (c) Calculate the weight of water condensed from 1000 ft^3 of gas. (d) Calculate the final volume of wet air leaving. Data: Vapour pressure of H_2O at 20°C =17.5 mm Hg and at 10°C = 9.2 mm Hg.	**(10)**	**3**	**3**
	(OR)			
(b)	An air (B)-water (A) sample has a dry bulb temperature of 50 °C and a wet bulb temperature of 35 °C. Estimate its molal humidity, partial pressure of water, percentage humidity, humid heat and the relative saturation at a total pressure of 1 atm. Molecular weight of air = 28.84	**(10)**	**3**	**3**
24.(a)	A natural gas has the following composition on mole basis: CH_4 – 84 %, C_2H_6 – 13 % and N_2 – 3 %. Formulate an empirical expression for heat to be added and calculate the heat to be added to raise the temperature of 10 kmol of natural gas from 298 K to 523 K using heat capacity data given below. $Cp° = a + bT + CT^2 + dT^3$, kJ/kmol.K	**(10)**	**4**	**3**

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	8.7149
N_2	29.5909	-5.141	13.1829	-4.968

	(OR)				
(b)	Dry methane and dry air at 298 K and 1 bar pressure are burnt with 100% excess air. The standard heat of reaction is –802 kJ/g mole of methane.	**(10)**	**4**	**3**

Determine the final temperature attained by the gaseous products if combustion is adiabatic and 20% of heat produced is lost to the surroundings. Data: C_{pm} values (J/g mole K) for the components are: O_2 : 31.9, N_2 : 32.15, H_2O : 40.19, CO_2 : 51.79.

		Marks	CO	RBT LEVEL
25.(a)	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) Analyze the C:H ratio in the fuel.	**(10)**	**5**	**3**
	(OR)			
(b)	The ultimate analysis of a coal sample is given as C – 61.5%, H_2 – 3.5%, S – 0.4%, Ash 14.2%, N_2 – 1.8% and rest oxygen. Calculate the theoretical oxygen requirement per unit weight of coal and the Orsat analysis of flue gases, if coal is burnt with 90% excess air.	**(10)**	**5**	**3**

PART- C (1x 10=10Marks)

(Q.No.26 is compulsory)

		Marks	CO	RBT LEVEL
26.	The average molecular weight of a flue gas sample is calculated by two different engineers. One engineer used the correct molecular weight of N_2 as 28, while the other used an incorrect value of 14. They got the average molecular weight as 30.08 and the incorrect one as 18.74. Calculate the % volume of N2 in the flue gases. If the remaining gases are CO_2 and O_2 calculate their composition also. Evaluate the error percentage of the faulty calculation.	**(10)**	**1**	**5**

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