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Question Paper Code: 50942

B.E. / B.Tech. DEGREE EXAMINATION, MAY 2017

Fourth Semester

Chemical Engineering

15UCH402 - CHEMICAL PROCESS CALCULATIONS

(Regulation 2015)

Duration: Three hours Maximum: 100 Marks

Answer ALL Questions

PART A - (10 x 1 = 10 Marks)

1. The number of moles of solute dissolved in one kilogram of solvent is called as

   (a) normality (b) molality
   (c) mole fraction (d) molarity

2. The volume occupied (m^3) by 40 kg of CO_2 gas at temperature of 273 K and pressure of 101300 N/m^2 is ____. Assume ideal gas law is applicable and take R = 8.314 J/gmol K. Molecular mass of CO_2 gas = 44 $gmol^{-1}$.

   (a) 20.4m^3 (b) 2.40 m^3 (c) 0.896 m^3 (d) 0.0203 m^3

3. In process industries, purging of recycle stream is done

   (a) to increase the rate of reaction (b) to recover valuable products
   (c) to limit the inert concentration (d) to maintain uniform temperature

4. A limiting reactant decides the _____ in chemical reactions.

   (a) equilibrium constant (b) conversion
   (c) operating condition (d) end point

5. The ratio of the actual absolute humidity to the saturation humidity is called

   (a) percentage humidity (b) molar humidity
   (c) relative humidity (d) dew point humidity

6. In humidity chart, the variable along the horizontal axis (X – axis) is

(a) wet bulb temperature (b) humidity
(c) saturation temperature (d) dry bulb temperature

7. Proximate analysis is used to determine the _____ content of coal sample.

(a) carbon (b) sulfur (c) volatile matter (d) hydrogen

8. The SI unit of heat capacity (C_P) is

(a) kJ/kg (b) J/kg K
(c) W/m K (d) it is a dimensionless quantity and hence no unit

9. The values for the standard heats of formation are _____ for exothermic reactions.

(a) positive whole number (b) infinite
(c) positive fractional number (d) negative

10. The heat of reaction depends mainly on

(a) temperature (b) reaction time
(c) volume of system (d) rate constant

PART - B (5 x 2 = 10 Marks)

11. What are basic units and derived units? Give examples for each.

12. Define bypass stream and recycle stream. Mention their uses in process industries.

13. From the following data's calculate the molar humidity and absolute humidity of air-water vapor mixture. At 25^{o}C, partial pressure of watervapor in the mixture = 2.0624 kPa and total pressure of the system = 100 kPa.

14. Define the following terms in combustion process: theoretical air and excess air.

15. Write the importance of air fuel ratio in combustion reaction.

PART - C (5 x 16 = 80 Marks)

16. (a) (i) An aqueous solution of acetic acid of 35% concentration (by mass) has density 1.04 kg/lit at 25^{o}C. Find the molarity, normality and molality of the solution. (12)

(ii) Sodium chloride weighing 600 kg is mixed with 200 kg potassium chloride. Calculate the mass % of NaCl in the mixture. (4)

Or

(b) (i) Air contains 21% oxygen and 79% nitrogen by volume. Calculate the average molar mass and composition by mass of air. (8)

(ii) A gas mixture contains 14% CO_2, 6 % O_2 and 80% N_2 by volume. It is at 204^oC and 102 kPa. Calculate the partial pressure of each component. (8)

17. (a) A saturated solution of $MgSO_4$ at 353 K (80^oC) is cooled to 303 K (30^oC) in a crystallizer. During cooling, mass equivalent to 4% solution is lost by evaporation of water. Calculate the quantity of the original saturated solution to be fed to the crystallizer per 1000 kg crystals of $MgSO_4.7H_2O$. The Solubility of $MgSO_4$ at 303 K (30^oC) and 353 K (80^oC) are 40.8 and 64.2 kg per 100 kg water respectively. The molar mass of $MgSO_4$ = 120.3 $gmole^{-1}$. (16)

Or

(b) (i) Explain the concept of limiting reactant and excess reactant with suitable example. (5)

(ii) Write down the general material balance equation for a process in which: chemical reaction occurs and no chemical reaction occurs. Explain the significance of terms in the equation. (5)

(iii) A sludge (wet solid) containing 70% water and 30% solid is passed through a drier, and the resulting product contains 25% water. How much water is evaporated per 1000 kg of sludge sent to the drier. (6)

18. (a) The humidity of air at 30^oC (86^oF) and a total pressure of 750 mmHg absolute (100 kPa) is 0.0055. calculate (i) the percent relative humidity (ii) the molal humidity and (iii) the partial pressure of the water vapor in the air. Data from the steam tables are: partial pressure of the water vapor in the air – water vapor mixture saturated at 30^oC = 31.8 mmHg = 4.242 kPa. (16)

Or

(b) Define and explain the measurement of following terms in humidification operations: dry bulb temperature, dew point, wet bulb temperature and absolute humidity. (16)

19. (a) The flue gas from an industrial furnace has the following composition by volume: CO_2 = 11.73%, CO = 0.2%, N_2 = 0.09%, O_2 = 6.81% and N_2 = 81.17%. Calculate the percentage excess air employed in the combustion if the loss of carbon in clinker and ash is 1% of the fuel used and the fuel has the following composition by weight: C = 74%, H_2 = 5%, O_2 = 5%, N_2 = 1%, S = 1%, H_2O = 9% and ash = 5%. (16)

Or

(b) (i) Pure methane is heated from 303 K to 523 K at atmospheric pressure. Calculate the heat added per kmol methane. Use the polynomial relation between heat capacity and temperature as, $C_p = a + b\,T + c\,T^2 + d\,T^3$. The values of the coefficients are: a = 19.2494, b = 52.1135 x 10^{-3}, c = 11.973 x 10^{-6} and d = – 11.3173 x 10^{-9}. (8)

(ii) Discuss the calculation for heat capacity of gaseous mixtures and heat capacity of liquid mixtures. (8)

20. (a) (i) In the production of sulfuric acid from anhydrite, the gypsum is roasted with clay to obtain sulfur dioxide and cement clinker. The reaction proceeds as follows: $3CaSO_{4(s)} + SiO_{2(s)} \rightarrow 3CaO.SiO_{2(g)} + 3SO_{2(g)} + (3/2)O_{2(g)}$. Calculate the heat of reaction at 25°C. Thermodynamic data's available are (8)

Component	ΔH_f^o at 25°C in kJ/mol
$CaSO_4$	– 1432.7
SiO_2	– 903.5
$3CaO.SiO_2$	– 2879
SO_2	– 296.81
O_2	0.0

(ii) Develop the energy balance equation of a process without chemical reactions for: (a) closed systems and (b) open systems with heat transfer into and out of the process. (8)

Or

(b) (i) Explain the effect of temperature and pressure on heat of reaction. (10)

(ii) With a suitable flow system as example, formulate the unsteady state energy balance equation and discuss the various terms involved in it. (6)

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