Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER– VI • EXAMINATION – SUMMER 2015

Subject Code: 163502 Date: 04/05/2015

Subject Name: Material & Energy Balance Calculation

Time: 10.30am-01.00pm Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Atomic weight: H:1, C:12, N:14, O:16, Cl=35.5, K=39, S:32, Cu=63.5.**

Q.1 **(a)** The Antoine equation predicts the effect of temperature on vapour pressure by the relation: **07**

$$\ln P^s = A - \frac{B}{T - C}$$

Where, A, B and C are Antoine constant s. For water, the values of the constants where the vapour pressure is in kPa and temperature is in K are found to be A = 16.26205, B = 3799.887 and C = 46.854. What are these values when Vapour pressure is in psia and temperature in ^{0}F.

(b) Calculate the pressure developed by one kmol gaseous mixture ammonia contained in a vessel of 0.6 m^3 capacity at a constant temperature of 473 K by using the van der waals equation given that a = 0.4233 N m^4/mol^2; b = 3.73 x 10^{-5} m^3/mol **07**

Q.2 **(a)** Explain Recycle, Purge, bypass with suitable diagram and also define the overall and single pass fraction conversion. **07**

(b) In an electrochemical cell, the current is passed at the rate of 1130 A for 18000 s through a solution containing copper sulphate. At the end of the process, 1.12 m^3 of oxygen (at NTP) is collected. Find (a) amount of copper liberated (b) the current efficiency of the cell. **07**

OR

(b) Define the following terms **07**

(1) Limiting component
(2) Yield
(3) selectivity,
(4) Overall conversion,
(5) Molality,
(6) Molarility
(7)Normality.

Q.3 **(a)** Soil contaminated with polyaromatic hydrocarbons can be treated with hot air and steam to drive out contaminates. If 30 m^3 of air at 100 ^{0}C and 98.6 kPa with a dew point of 30 ^{0}C are introduced into the soil, and in soil the gas cools to 14 ^{0}C at a pressure of 109.1 kPa, what fraction of the water in the gas at 100 ^{0}C condenses out in the soil? Vapour pressure of water at 30 ^{0}C and 14 ^{0}C are 4.24 kPa and 1.60 kPa respectively. **07**

(b) The average molecular weight of the 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 and the incorrect one as 18.74. Calculate the % volume of N_2 in the flue gases. If the remaining gases are CO_2 and O_2 calculated their **07**

compositions also.

OR

Q.3 **(a)** A saturated solution containing 1500 kg of potassium chloride at 360 K is cooled in an open tank to 290 K. If the specific gravity 1.2, the solubility of KCl per 100 parts of water is 53.55 at 360 K and 34.5 at 290 K, calculated **07**

(a) The capacity of the tank required

(b) The weight of crystals obtained neglecting the loss of the water by evaporation

(b) Waste acid from a nitrating process contain 25 % HNO_3 , 55 % H_2SO_4 and 20 % H_2O by weight. This is to be concentration to get fortified acid containing 27 % HNO_3, 60 % H_2SO_4, and 13 % water. This is done by adding concentrated H_2SO_4 of strength 93 % H_2SO_4 and concentrated H_2SO_4 and concentrated HNO_3 of strength 90 % HNO_3 in suitable quantities to the waste acid. If 1000 kg fortified acid is to be produced, calculated the kg of the various solutions mixed? **07**

Q.4 **(a)** A heat exchanger for cooling a hot hydrocarbon liquid uses 10000 kg/h of cooling water, which enters the exchanger at 294 K. The hot oil at the rate of 5000 kg/h enters at 423 K and leaves at 338 K and has an average heat capacity of 2.5 kJ/kg K. Calculate the outlet temperature of water. **07**

(b) Using Watson equation, calculate latent heat of vaporization of **07**

(a) Acetone at 313K

(b) Carbon disulphide (CS_2) at 413 K.

T_1 (boiling point temp)	Component	Latent heat of vaporization at T_1, K (KJ/kmol)	T_c	n
329.4	Acetone (C_3H_6O)	29121	508.1	0.38
319	CS_2	26736	552.0	0.38

OR

Q.4 **(a)** Pure methane is heated from 303 K to 523 K at atmospheric pressure. Calculate the heat added per kmol methane using the following data: **07**

$C_p = 19.2494 + 52.1135 \times 10^{-3}T + 11.973 \times 10^{-6}T^2 - 11.317 \times 10^{-9}T^3$ $^{KJ}/_{(kmol\,K)}$

(b) Calculated the enthalpy of zinc vapour at 1200 ^{0}C and atmosphere pressure, relative to solid at 10 ^{0}C. **07**

Data: Melting point of Zn = 419 ^{0}C (at 1 atm)
Boiling point of Zn = 907 ^{0}C (at 1 atm)
Mean C_p of solid Zn = 0.105 kcal/kg ^{0}C
Mean C_p of liquid Zn = 0.109 kcal/kg ^{0}C
Heat of fusion of Zn = 1660 kcal/kgmole
Heat of vaporization of Zn = 26900 kcal/kgmole
Mean Cp of Zinc vapour = 4.97 kcal/kgmole ^{0}C
Atomic weight of Zn = 65.4 kg/kgmole

Q.5 **(a)** Define the following terms: **07**

i. Dry-bulb temperature

ii. Wet bulb temperature

iii. Latent heat
iv. Absolute humidity
v. Percentage humidity
vi. Dew point
vii. Humid heat

(b) The heat of reaction at 300 K and 1 atm pressure for the reaction A+3B →C is -30,000 cal/mole A converted. **07**
Cp data (cal/mole K) is as follows: A = -0.4 + 0.1 T (T in K), B = 10, C = 30.
Calculated the heat of reaction at 600 K and 1 atm.

OR

Q.5 **(a)** Calculate the theoretical flame temperature of gas having 20 % CO and 80 % N_2 burnt with 150 % excess air. Both air and gas are being at 25 ^{0}C. **07**
Data: heat of formation of CO_2 = -94,052 cal /gmol , CO = -26,412 cal/ gmol at 25 ^{0}C.
C_{pm} : CO_2 = 12.1 , O_2 = 7.9 , N_2 = 7.55 cal/ gmol K.

(b) Differentiate between: (i) Sensible heat and latent heat (ii) Endothermic and exothermic reactions. **07**

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