Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–III (NEW) • EXAMINATION – SUMMER 2015

Subject Code: 2133606 Date: 04/06/2015

Subject Name: Material & Energy Balance Calculations

Time:02.30pm-05.00pm 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, Na:23, Cl=35.5, K=39, S:32, Cu=63.5.**

Q.1 **(a)** The thermal conductivity of an insulating brick is 0.15 BTU/ (ft h ^{0}F). Express the thermal conductivity in SI units. **07**

(b) A weight of 1.10 kg of Carbon dioxide occupies a volume of 33 liter at 300 K. Using the Van der Waals equation of state, calculate the pressure. Data: For CO_2 , take a = 3. 60 $[(m^3)^2\text{-kPa}]/(kmol)^2$and b = 4.3 x 10^{-2} m^3/kmol. **07**

Q.2 **(a)** 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 compositions also. **07**

(b) Write short note on recycling, bypassing and purging operations. **07**

OR

(b) An aqueous solution of K_2CO_3 is prepared by dissolving 44 g K_2CO_3 in 100 g water at 293 K. Find molarity, normality and molality of the solution. Take density of solution as 1.3 kg/lit. **07**

Q.3 **(a)** A weak acid containing 12.5 % H_2SO_4 and the rest water is fortified by adding 500 kg of concentrated acid containing 80 % H_2SO_4. Determine the amount of the solution obtained if it contains 18.5 % H_2SO_4? **07**

(b) A soap plant produced raw soap containing 50 % moisture. This is to be dried 20 % moisture before it is pressed into cakes for sale. How many 100 g soap piece can be obtained from 1000 kg of original raw soap? **07**

OR

Q.3 **(a)** Fifty kilograms of dry sodium bicarbonate is to be crystallized and removed from 1000 kg of a saturated solution at 333 K. To what temperature the solution is to be cooled, if the solubility data is as follows? **07**

Temperature (K)	333	323	313	303	293	283
Solubility $\frac{kg\ bicarbonate}{100\ kg\ water}$	16.4	14.5	12.7	11.1	9.6	8.2

(b) Air at 298 K, 55% saturated with water vapour, is initially at 100 kPa. It is then compressed to 1000 kPa and cooled to a temperature so that 90% of the water vapour is condensed. Calculated the following: **07**

(i) The final temperature of the air
(ii) The volume of final air per cubic meter of original air.

The vapour pressure of water in kPa is given by the Antoine equations (T is temp. in ^{0}K)

$$\ln P^S = 16.26205 - \frac{3799.887}{T - 46.854}$$

Q.4 **(a)** 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

(b) 1. How many joules are needed to heat 60 kg of sulphur trioxide from 273.16 K to 373.16 K ? **07**

$$Cp_{SO_3} = 34.33 + 42.86 \times 10^{-3}T - 13.21 \times 10^{-6}T^2 \frac{J}{mole\ K}$$

OR

Q.4 **(a)** 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

(b) The molal heat capacity of CO is given by **07**

$$C_p = 26.586 + 7.582 \times 10^{-03}T - 1.12 \times 10^{-06}T^2\ {}^{KJ}/_{(kmolK)}$$

Calculate the mean molal heat capacity in the temperature range of 500-1000 K.

Q.5 **(a)** Differentiate between: (i) Sensible heat and latent heat (ii) Endothermic and exothermic reactions. **07**

(b) 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

OR

Q.5 **(a)** **07**

$$SO_2 + \frac{1}{2}O_2 \rightarrow SO_3$$

Calculate the heat of reaction at 700 K using the following.
Cp^0= a +bT + cT^2 KJ/Kmol K

Comp.	ΔH^0_f (kJ/mole) at 298 K	a	b x 10^3	c x 10^6
SO_2	-296.81	24.77	62.95	-44.26
O_2	0.0	26.026	11.755	-2.3426
SO_3	-395.72	22.04	121.6	-91.87

(b) 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.

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