Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–IV(New) EXAMINATION – SUMMER 2016

Subject Code:2143507 **Date:08/06/2016**

Subject Name:Fundamentals of Stoichiometry

Time:10:30 AM to 01:00 PM **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

MARKS

Q.1 Short Questions **14**

1 One Btu of heat is supplied to one kilogram of water. What will be the temperature rise for water?

(a) 0.252 ^{0}C (b) 1 ^{0}C
(c) 3.97 ^{0}C (d) 4.186 ^{0}C

2 Two bottles A and B are filled with 100 g each of HNO_3 and H_2SO_4 respectively. Which one of the following statement is true?

(a) Bottles A contains more molecules (b) Bottles B contains more molecules
(c) Bottles A and B contain the same number of molecules (d) Bottles A and B contain the same number of moles

3 The molarity of water in pure water is

(a) 1 (b) 18
(c) 55.55 (d) Infinity

4 Two effluent streams are mixed. One stream contains 10 % salt and the other none. The combined stream contains 2 % salt. The ratio of the two stream are

(a) 1:4 (b) 1:5
(c) 1:2 (d) 1:8

5 The vapour pressure of an organic liquid is given by the Antoine equation

$$\ln P^s = 14.5463 - \frac{2940.46}{T - 49.19}$$

Where P^s is in kPa and T is in K. What is the normal boiling point of the substance

(a) 373.2 K (b) 1022.8 K
(c) 345.4 K (d) 283.7 K

6 The solubility of gases in liquid at a given partial pressure

(a) Directly proportional to the (b) Inversely proportional to
(c) Increases with increasing (d) Not related to the

7 Which of the following statements is true with regards to the percent saturation(PS) and relative saturation(RS) ?

(a) PS = RS (b) PS > RS

(c) PS < RS
(d) PS and RS are not interrelated

8 Adiabatic saturation temperature of a vapour-gas mixture is

(a) The steady-state temperature attained by the liquid evaporating into gas
(b) The temperature to which the gas can be cooled at constant
(c) The temperature attained by the gas when it is humidified to saturation in contact with the liquid at constant temperature
(d) The temperature at which the existing vapour content is sufficient to saturate the gas

9 A mixture of ethyl acetate vapour and air has a relative saturation of 50% at 303 K and a total pressure of 100 kPa. If the vapour pressure of ethyl acetate at 303 K is 16 kPa, the percent of air is

(a) 92 %
(b) 45.7 %
(c) 50 %
(d) 8 %

10 Pure carbon is completely burnt in oxygen. The flue gas analysis is 70% CO_2 , 20 % CO, and 10 % O_2. The percent excess oxygen used is

(a) 20
(b) 12.5
(c) 0
(d) 10

11 A butane isomerisation process produces 70 kmol/hr of pure isobutene. A purge stream, removed continuously, contains 85 % n-butane and 15 % impurity (mole %). The feed stream is n-butane containing 1% impurity. The flow rate of the purge stream will be

(a) 3 kmol/hr
(b) 4 kmol/hr
(c) 5 kmol/hr
(d) 6 kmol/hr

12 The maximum flame temperature is attained

(a) When the fuel and air are in stoichiometric quantities
(b) When fuel is burned with an excess of pure oxygen
(c) When stoichiometric amount of oxygen is used
(d) When excess of air supply is provided

13 A batch adiabatic reactor at an initial temperature of 373 K is being used for the reaction A → B. assume that the heat of reaction is -1 kJ/mol at 373 K and the heat capacity of both A and B to be constant and equal to 50 J/mol K. The temperature rise after a conversion of 0.5 will be

(a) 5 K
(b) 10 K
(c) 20 K
(d) 100 K

14 An insulated container holds 20 kg of water initially at 298 K. It is stirred by an agitator, which is made to turn by body weighing 40 kg slowly falling through a height of 4 m. the process is repeated 500 times. The acceleration due to gravity is 9.8 m/s^2. Neglecting the heat capacity of the agitator, the temperature attained by the water is

(a) 313.3 K
(b) 307.4 K
(c) 299.8 K
(d) 298 K

Q.2 (a) Define : (1) limiting reactant (2) Amagat's law (3) partial pressure **03**

(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. **04**
Data: For CO_2 , take a = 3.60 $[(m^3)^2\text{-kPa}]/(\text{kmol})^2$ and b = 4.3 x 10^{-2} m^3/kmol

(c) The heat capacity of sulphur is Cp = 15.2 + 2.68T , where Cp is in J/(gmol K) and T is in K. Convert that Cp is in cal/(gmol ^{0}F) with T in ^{0}F. **07**

OR

(c) 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**

Q.3 (a) Explain Recycle, Purge, bypass with suitable diagram **03**

(b) The gaseous reaction A = 2B + C takes place isothermally in a constant-pressure reactor. Starting with a mixture of 75 % A and 25 % inerts (by volume), in a specified time the volume double. Calculate the conversion achieved. **04**

(c) 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 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

OR

Q.3 (a) Draw a P-T chart for water. Label the following clearly: vapour pressure curve, dew point curve, saturated region, superheated region, subcooled region and triple point **03**
Show where vapourization, condensation and sublimation take place by arrows.

(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 ? **04**

(c) In the BASF oil quench process to manufacture acetylene; pure oxygen and pure methane are fed to the acetylene burner. The cracked gas from the burner has the following composition: **07**
H_2: 56.5 %, CH_4: 5.2 %, C_2H_4: 0.3 %, C_2H_2: 7.5 %, C_3H_6: 0.5 %, CO: 25.8 %, CO_2: 4.0 %, and O_2:0.2 % (mole % on dry basis).
Assume that formation of the other compounds, such as ammonia, is negligible.
For 100 kmol cracked gas, calculate (a) methane requirement (b) oxygen requirement (c) production of water

Q.4 (a) Define : (1) Yield (2) selectivity (3) ^{0}API **03**

(b) Heat capacity for gaseous SO_2 is given by the following equation: **04**
$C^0 = 43.458 + 10.634 \times 10^{-3}T - 5.945 \times 10^5/T^2$
Calculated the heat required to raise the temperature of 1 kmol pure SO_2 from 300 K and 1000 K.

(c) 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

OR

Q.4 **(a)** Define: (1) single pass conversion (2) overall conversion (3) ^{0}Be` **03**

(b) Using Watson equation, calculate latent heat of vaporization of Acetone at 313K **04**

T1 (boiling point temp)	Component	Latent heat of vap at T_1, K (KJ/kmol)	T_c	n
329.4	Acetone (C_3H_6O)	29121	508.1	0.38

(c) 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**

Q.5 **(a)** Define : (1) Heat Capacity (2) Enthalpy (3) Internal Energy **03**

(b) Calculate the heat of reaction for the esterification of ethyl alcohol with acetic acid if the standard heats of combustion are : ethyl alcohol: -1366.91 kJ/mol, acetic acid: -871.69 kJ/mol, ethyl acetate: -2274 kJ/mol. **04**

(c) Calculate the heat of reaction at 700 K using the following reaction. **07**

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

Data: Cp^0= a +bT + cT^2 KJ/Kmol K

Comp.	$\Delta H^0_{f,298\ K}$ (kJ/mol)	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

OR

Q.5 **(a)** Define: (1) Wet bulb temperature (2) Absolute humidity (3) bubble point **03**

(b) Calculate the heat of formation of $CHCl_3$ from the following data: **04**

$CHCl_3 + \frac{1}{2}O_2 + H_2O \rightarrow CO_2 + 3HCl, \Delta H = -509.93\ kJ$ .... (1)

$H_2 + \frac{1}{2}O_2 \rightarrow H_2O, \Delta H = -296\ kJ$ ... (2)

$C + O_2 \rightarrow CO_2$ ... (3)

$CO_2 + 3HCl \rightarrow CHCl_3 + \frac{1}{2}O_2 + H_2O, \Delta H = -509.93\ kJ$ ...(4)

(c) Calculate the theoretical flame temperature for CO when burned with 100 % excess air when both the reactants are at 373 K. the heat capacities (J/mol K) may be assumed constant at 29.23 for CO, 34.83 for O_2, 33.03 for N_2 and 53. 59 for CO_2. The standard heat of combustion at 298 K is -298.99 kJ/mol CO. **07**

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