Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–III (New) EXAMINATION – WINTER 2015

Subject Code: 2133606 **Date:29/12/2015**

Subject Name: Material and Energy Balance Calculation

Time: 2:30pm to 5:00pm **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,S-32,Cl-25.5, K-39,**

MARKS

Q.1 Short Questions

1 The rate of material _____ is zero in case of a steady state system. **1**

(a) accumulation (b) production
(c) input (d) generation

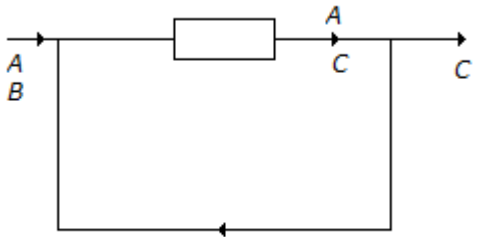
2 A 'limiting reactant' is the one, which decides the _____ in the chemical reaction. **1**

(a) equilibrium constant (b) conversion
(c) rate constant (d) none of these

3 A vapour whose partial pressure is less than its equilibrium vapour pressure is called the _____ vapour. **1**

(a) saturated (b) superheated
(c) unsaturated (d) dry gaseous

4 The reaction A + B → C has been conducted in a reactor as shown below. The number of boundaries around which material balance can be written, are **1**



(a) 1 (b) 6
(c) 3 (d) 4

5 Which of the following gravity scales is used exclusively for liquids heavier than water? **1**

(a) Baumme scale (b) Twaddel scale
(c) API scale (d) none of these

6 What is the simplest formula of a compound containing 50% of **1**

(a) AB_3 (b) A_2B_3
(c) A_2B (d) AB_2

7 Real gases approach ideal behaviour at **1**

(a) high pressure & high Temptemperature. (b) low pressure & high temperature.

(c) high pressure & low temperature. (d) low pressure & low temperature.

8 Internal energy of a substance comprises of the _____ energy. **1**

(a) vibrational (b) rotational
(c) translational (d) all (a), (b) & (c)

9 The net heat evolved or absorbed in a chemical process, i.e. total change in the enthalpy of the system is independent of the **1**

(a) temperature & pressure. (b) number of intermediate chemical reactions
(c) state of aggregation & the state of combination at the beginning & the end of the reaction. (d) none of these.

10 The heat change for the reaction, $C(s) + 2S(s) \rightarrow CS_2(l)$, is 104.2 kJ. It represents the heat of **1**

(a) formation (b) solution
(c) combustion (d) fusion

11 1 Kcal/kg. °C is equivalent to _____ BTU/lb. °F. **1**

(a) 1 (b) 2.42
(c) 4.97 (d) None of these

12 (1) Which of the following is the Claussius-Clayperon **1**

(a) $PV = RT + B/V + y/V^2 + ...$ *(b)* $(P + a/V^2)(V\text{-}b) = RT$

(c) $\log_e \frac{p}{p_0} = \frac{\lambda}{R}\left(\frac{1}{T_0} - \frac{1}{T}\right)$ *(d)* $p = \frac{RT}{V - b} - \frac{a}{TV^2}$

13 At standard conditions, **1**

$N_2 + 2O_2 \rightleftharpoons 2NO_2$; $\Delta H° = 100$ kJ/mole

$NO + \frac{1}{2}O_2 \rightleftharpoons NO_2$; $\Delta H° = -35$ kJ/mole

(a) 15 (b) 30
(c) 85 (d) 170

14 Heat of reaction is not influenced by **1**

(a) the route/method through which final products are obtained. (b) the physical state (e.g., solid, liquid or gaseous) of reactants and products.
(c) whether the reaction is carried out at constant temperature or constant pressure. (d) none of these.

Q.2 **(a)** Define (1) conversion, (2) yield, (3) selectivity **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 $[(m^3)^2\text{-kPa}]/(kmol)^2$
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 **07**

T in ^{0}F.

OR

(c) 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 mm Hg and temperature in ^{0}C .

Q.3 **(a)** Define (1) dew point (2) relative humidity (3) humid heat **03**

(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

OR

Q.3 **(a)** Draw neat sketch of Recycle, bypass and purge operations **03**

(b) 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 **04**
The capacity of the tank required

(c) 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. **07**

Q.4 **(a)** Define (1) Molarity, (2) Normality (3) Mole fraction **03**

(b) Air being compressed from 100 kPa and 255 K (enthalpy 489 kJ/kg) to 1000 kPa and 278 K (enthalpy 509 kJ/kg). The exit velocity of air is 60 m/s. what is the power required (in kW) for the compressor if the load is 100 kg/hr of air ? **04**

(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)** Give the statements of (1) Henry's law (2) Raoult's Law (3) **03**

Dalton's law

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

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

Q.5 **(a)** Differentiate between sensible heat and latent heat **03**

(b) For the following reaction , estimate the heat of reaction at 298 K **04**

A + B → C + D

Data: $\Delta H^0_{f,A}$ = -269.8 kcal/gmol , $\Delta H^0_{f,B}$ = -195.2 kcal/gmol, $\Delta H^0_{f,C}$ = -337.3 kcal/gmol , $\Delta H^0_{f,D}$ = -29.05 kcal/gmol

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

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

Cp^0= a +bT + cT^2 kJ/(kmol K)

Comp.	$\Delta H^0_{f,298}$(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) standard heat of formation (2) standard heat of reaction (3) adiabatic flame temperature **03**

(b) 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. **04**

(c) 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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