



KC-8043

B. E. - II (Sem. III) (Chem.) Examination
November / December – 2012
Process Calculation
(New Syllabus)

Time : 3 Hours]

[Total Marks : 100

Instructions : (1)

नीचे दृशविले निशानीवाणी विगतो उत्तरवही पर अवश्य लखवी. Fillup strictly the details of signs on your answer book.	Seat No. :
Name of the Examination :	<input type="text"/>
<input type="text" value="B. E. - 2 (SEM. 3) (CHEM.)"/>	<input type="text"/>
Name of the Subject :	<input type="text"/>
<input type="text" value="PROCESS CALCULATION (NEW)"/>	<input type="text"/>
Subject Code No. : <input type="text" value="8"/> <input type="text" value="0"/> <input type="text" value="4"/> <input type="text" value="3"/>	<input type="text" value="Student's Signature"/>
Section No. (1, 2,.....): <input type="text" value="NIL"/>	

- (2) Attempt all questions.
- (3) Figures to the right indicate full marks.
- (4) Assume suitable data whenever necessary.

1 (a) Attempt the following :

10

- (i) Convert 127 lb/ft³ into g/cm³
- (ii) Convert volumetric flowrate of 2 m³/s to l/s.
- (iii) Calculate kg of C_{Na}1 of which amount is specified as 3 Katom.
- (iv) What is STP ?
- (v) Define limiting reactant.
- (vi) Define Purge Ratio.
- (vii) Write expression of density of gas mixture.
- (viii) Why recycling is done in unit process ?
- (ix) Convert 88 kg of CO₂ into its Kmol.
- (x) Convert 1000 dyne into Newton.

- (b) (i) A producer gas has following composition by volume 5
 $\text{CO} = 21\%$, $\text{CO}_2 = 5\%$, $\text{O}_2 = 3\%$ and balance being N_2 . Calculate the volume of gas in m^3 at 298K and 99.325 KPa per kg. of Carbon present.
- (ii) A chemist is interested in preparing 500 ml of 1 nor- 5
 mal, 1 molar and 1 molal solution of H_2SO_4 . Assuming the density of H_2SO_4 solution to be 1.075 g/cm^3 , calculate the quantities of H_2SO_4 to be taken to prepare these solutions.

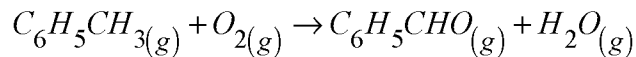
2 Attempt the following : (any two) 7×2=14

- (a) In manufacture of HCl, gas containing 20% HCl and 80% air by volume enters an absorption tower at a temperature of 323K and pressure of 99.325 KPa. 98% of HCl is absorbed in water and remaining gas leaves the tower at a temperature of 293K and pressure of 97.992 KPa. Calculate :
- (i) The wt. of HCl absorbed per m^3 of gas entering the system.
- (ii) The volume of gas leaving per m^3 of gas entering the system.
- (b) An evaporator system containing a weak liquor from 5% to 50% solids handles 100 kg of solids per hour. If the system is to concentrate a weak liquor from 4% to 35%, find the capacity of the system in terms of solids that can be handled per hour assuming water evaporation capacity to be same in both the cases.
- (c) The average molecular weight of a flue gas sample is calculated by two different engineers. One engineer uses the correct molecular wt. of 28 for N_2 and determine the average molecular weight to be 30.08, the other engineer using an incorrect value of 14, calculates the average molecular weight to be 18.74 calculate :
- (i) The volume of N_2 in flue gases.
- (ii) If the remaining components of the flue gases are CO_2 and O_2 ; calculate the volume % of each of them.

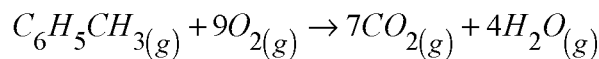
3 Attempt the following : (any two)

8×2=16

- (a) In the manufacture of benzaldehyde a mixture containing dry air and toluene is fed to the converter at a temperature of 448K and 100 kpa of pressure. The mixture passes through the catalyst bed in the converter. The product gas stream leaves the converter at 468K the reaction takes place as follows :



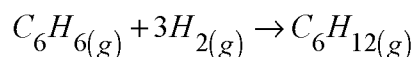
The dry air is supplied at 100% excess so as to maintain the high yield of benzaldehyde. The side reaction taking place is :



At the above mentioned conditions the overall conversion is 13% based on toluene.

Approximately 0.5% of the toluene charged burns to CO_2 and H_2O . Calculate the composition of gas stream leaving the converter.

- (b) Gaseous benzene reacts with hydrogen in presence of Ni catalyst as per the reaction.



30% excess hydrogen is used above that required by given reaction. Conversion is 50% and yield is 90% calculate the requirement of benzene and hydrogen gas for 100 moles of cyclohexane.

- (c) (i) The feed to a continuous distillation column analyses by weight 28 percent benzene and 72 percent toluene. The analysis of distillate shows 52 weight percent benzene and 5 weight percent benzene was found in the bottom product. Calculate the amount of distillate and bottom product per 1000kg of feed per hour. Also calculate the % recovery of benzene.

- (ii) An effluent sample from a formaldehyde plant is known to contain methanol and formaldehyde. The analysis of the solution indicated that TOC and ThOD are 258.3 mg/l and 956.5 mg/l respectively. Find the concentration of each of the compounds in the sample.

4 (a) Define the following : 8

- (i) First law of thermodynamics
- (ii) Heat of reaction
- (iii) excess air
- (iv) Specific heat of substance
- (v) Hess law
- (vi) Antonie equation
- (vii) Internal energy
- (viii) $NCV = GCV - \underline{\hspace{2cm}}$

- (b) Calculate NCV at 298K at a sample of fuel oil having C/H ratio 9.33 (by weight) and containing sulphur to the extent of 1.3%.

Data : GCV of fuel oil at 298K = 41785 kJ/kg.

Latent heat of water vapour = 2442.5 kJ/kg.

5 Attempt any two : 8×2=16

- (a) Calculate the GHV and NHV at 298 K of the gas having following composition by volume :

$CH_4 = 74.4\%$, $C_2H_6 = 8.4\%$, $C_3H_8 = 7.4\%$, $i-C_4H_{10} = 1.7\%$

$n-C_4H_{10} = 2.0\%$, $i-C_5H_{12} = 0.5\%$, $n-C_5H_{12} = 0.4\%$

$N_2 = 4.3\%$ and $CO_2 = 0.9\%$

Data :

Component	GCV, kg/mol	NCV, kj/mol
CH_4	890.65	802.62
C_2H_6	1560.69	1428.64
C_3H_8	2219.17	2043.11
$i-C_4H_{10}$	2868.20	2648.12
$n-C_4H_{10}$	2877.40	2657.32
$i-C_5H_{12}$	3528.83	3264.73
$n-C_5H_{12}$	3535.77	3271.67

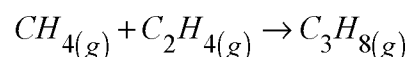
Sp. volume of gas at 298K and 101.325kPa
 = 24.465 m³/kmol.

- (b) Heat capacity data for gaseous SO_2 is given by the following equation :

$$C_p = 43.458 + 10.634 \times 10^{-3} T - 5.945 \times \frac{10^5}{T^2} \quad \text{calculate heat}$$

needed to raise the temperature of 1 kmol pure sulphur dioxide from 300K to 1000K.

- (c) Obtain an empirical equation for calculating the heat of reaction at any temperature T(in K) for following reaction :



Data :

$$\Delta H_R \text{ at } 298K = -82.66 \text{ kJ/mol.}$$

$$C_p = a + bT + cT^2 + dT^3$$

Component	a	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$
CH_4	19.2494	52.1135	11.973	-11.3173
C_2H_4	4.1261	155.0213	-81.5455	16.9755
C_3H_8	-4.2227	306.264	-158.6316	32.1455

6 Attempt any two :

9×2=18

- (a) (i) Calculate the standard heat of reaction at 298.15 K when gaseous ammonia is dissolved in water to form 2% by weight ammonia solution.

Data :

Component	$\Delta H_f^\circ, kJ/mol$
$NH_{3(g)}$	-49.94
$NH_4OH(l)$	-361.20
$H_2O(l)$	-285.83

- (ii) The gross calorific value of liquid, acetone at 298 K is 1791.21 kJ/mol. Find its NCV using latent Heat of water at 298 K. 4

- (b) A mixture of Diphyl D.T. is used, as a thermic fluid in a liquid phase heating system. The thermic fluid enters an indirect fired heater at 180°C and leaves it at 260°C. The heat capacity of fluid is given by.

$$C_1 = 1.436 + 0.00218 T \text{ (kJ/kg.K)}$$

where T is in K.

- (i) Calculate the supply of heat in heater per kg of liquid heated.
- (ii) If the heat capacity of Diphyl DT at 180°C and 260°C are 2.03 and 2.206 kJ/kg.K. respectively, how much error will be involved in the computation of heat load using the mean heat capacity value ?

(c) The ultimate analysis of coal sample is give below :
Carbon = 61.5%, Hydrogen = 3.5%, Suphur = 0.4%
ash -14.2%, Nitrogen=1.8% and rest Oxygen

Calculate :

- (i) Theoretical Oxygen requirement per unit weight of coal.
 - (ii) Theoretical dry air requirement per unit weight of coal and
 - (iii) The orsat analysis of flue gases when coal is burned with 90% excess dry air.
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