

Name :

Roll No. :

Invigilator's Signature :

CS/B.TECH(BT & FT)(NEW)/SEM-4/CH-401/2012
2012
INDUSTRIAL STOICHIOMETRY

Time Allotted : 3 Hours

Full Marks : 70

The figures in the margin indicate full marks.

*Candidates are required to give their answers in their own words
as far as practicable.*

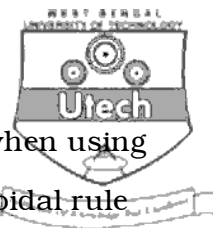
GROUP – A

(Multiple Choice Type Questions)

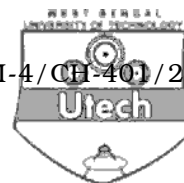
1. Choose the correct alternatives for any *ten* of the following :

$10 \times 1 = 10$

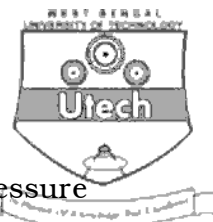
- (i) Slope of straight line in the log-log plot can be expressed as
- a) $(y_2 - y_1) / (\log x_2 - \log x_1)$
 - b) $\log(y_2 - y_1) / (\log x_2 - \log x_1)$
 - c) $(y_2 - y_1) / (x_2 - x_1)$
 - d) none of these.
- (ii) A mathematical expression is represented by $y = 0.68(0.084)^x$. The type of graph paper fitted for this equation will be
- a) rectangular
 - b) log-log
 - c) semi-log
 - d) none of these.



- (iii) Graphical integration is more accurate when using
- Rectangular rule
 - Trapezoidal rule
 - Simpson's rule
 - None of these.
- (iv) Standard enthalpy of reaction is measured at
- 303 K and 10 K Pa
 - 303 K and 100 kPa
 - 298 K and 1 atm
 - all of these.
- v) The Molal Humidity to Absolute Humidity conversion factor is
- 0.72
 - 0.52
 - 0.62
 - 0.064.
- vi) Unit of enthalpy is
- kJ / (kg. K)
 - kJ/(kg mole. K)
 - kJ/K
 - kJ.
- vii) $C_{p_{mix}} = \sum x_i C_{p_i} \quad (1 < i < n)$
- The component gases are inert to each other
 - At least one gaseous component is inert
 - Most of the components are inert
 - None of these.
- viii) For 100% yield, selectivity is
- 1
 - $\frac{1}{2}$
 - 0
 - ∞ .
- ix) Ideal solution obeys
- Boyles law
 - Amagat's law
 - Raoult's law
 - all of these.



- x) Average molecular weight of a mixture of O_2 and other gases is calculated to be 23.2 using an incorrect value of 16 for the molecular weight of O_2 whereas the correct value of that is 29.6. What is the volume % of O_2 in the mixture ?
- a) 40 % b) 60 %
c) 50 % d) 28 % .
- xi) Purging operation is performed on recycled stream for
- a) increasing yield
b) reducing the accumulation of inerts
c) conserving heat
d) improving efficiency.
- xii) The actual flame temperature is less than adiabatic flame temperature. This is due to
- a) loss of heat
b) incomplete combustion
c) energy expended for performing mechanical work and increasing external kinetic and potential energies
d) all of these.
- xiii) An exothermic reaction takes place in an adiabatic reactor. The product temperature.....the reactor temperature.
- a) is always equal to
b) is always greater than
c) is always less than
d) may be greater or less than.



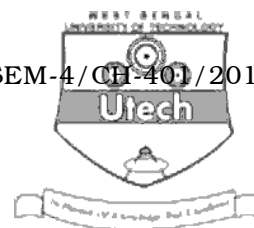
- xiv) The heat of reaction is
- independent of temperature and pressure
 - independent of temperature but changes with pressure
 - independent of number of intermediate steps involved
 - independent of state of aggregation of the reactants and products.
- xv) Proximate analysis of coal gives
- carbon, hydrogen and ash
 - carbon, hydrogen, sulphur and nitrogen
 - volatile matter, moisture, ash and fixed carbon
 - volatile matter, moisture, nitrogen and carbon.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

- The average molecular weight of a flue gas sample (containing CO_2 , N_2 , O_2) is calculated by two different ways. In one way using the correct molecular weight of N_2 (28) the average molecular weight comes 30.08 and in another way using the incorrect value of molecular weight for N_2 (14) results the average molecular weight of the flue gas of 18.74. Calculate the volume percentage of CO_2 , N_2 and O_2 in the flue gas.
- Distinguish between graphical integration and graphical differentiation.
- Write short note on any *one* of the following topics :
 - Bypass operation
 - Recycle operation.
- State Buckingham *Pi*-theorem with example.
- Define heat of combustion, % of conversion, absolute humidity and relative humidity.



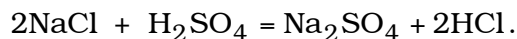
GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

7. a) What do you understand by the term 'selectivity' ?
Define limiting reactant and excess reactant in a chemical process with example. $2 + 2 + 2$

- b) Estimate the consumption of 96% NaCl and 93% H_2SO_4 for the production of 600 kg HCl if the conversion is 95%. Also calculate the amount of Na_2SO_4 produced during process. HCl is produced according to the reaction—

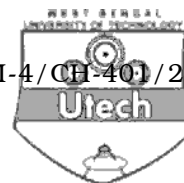


Molecular weights of NaCl, H_2SO_4 , Na_2SO_4 and HCl are 58.5, 98, 142 and 36.5, respectively. 9

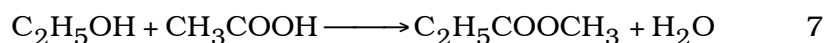
8. a) The spent acid from a Nitrating process contains 37% H_2SO_4 , 36% HNO_3 and 27% H_2O by weight. This acid is to be strengthened by the addition of conc. H_2SO_4 containing 95% H_2SO_4 and conc. HNO_3 containing 78% HNO_3 . The strengthened mixed acid is to contain 40% H_2SO_4 and 43% HNO_3 . Calculate the quantity of spent acid and the concentrated acids that should be mixed together to yield 1500 kg of the desired mixed acid. 5



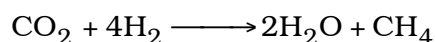
- b) Write the steps for material balance calculation. 5
- c) Define enthalpy of water vapour-air mixture, dry bulb temperature, dew point, heat of the reaction, percentage of yield. 5
9. a) 1000 kg of Na_2CO_3 solution containing 25% Na_2CO_3 is subjected to evaporative cooling during which process 15% of the water present in the solution is evaporated. From the concentric solution $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ crystallizes out. Calculate how much crystals would be produced if the solubility of $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ is 21.5 gm per 100 gm of H_2O . 5
- b) 1000 kg impure limestone containing 96% CaCO_3 and 4 % inert material is reacted with a H_2SO_4 acid solution containing 70% H_2SO_4 and 30% H_2O . The reacting mass is heated and all the CO_2 generated is driven off together with some of water vapour. The analysis of final solid mixture is as follows :
- $\text{CaSO}_4 = 86.54\%$, $\text{CaCO}_3 = 3.11\%$, $\text{H}_2\text{SO}_4 = 1.35\%$, $\text{H}_2\text{O} = 6.23\%$, inerts = 2.77%.
- Calculate :
- the degree of completion of reaction
 - mass of acid solution fed
 - mass of gas driven off
 - composition of gases driven off. 10



10. a) Calculate the heat of reaction for the esterification of ethyl alcohol with acetic acid if the standard heat of combustion are : ethyl alcohol = -1366.91 kJ/mol, acetic acid = -871.69 kJ/mol, ethyl acetate = -2274.48 kJ/mol.

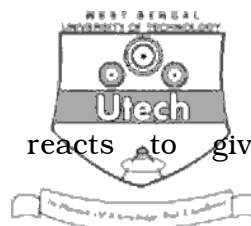


- b) For the following gas phase reaction, determine the heat of reaction at 800 K : 8



The standard heats of formation are -393.51 kJ/mol for CO_2 , -241.826 kJ/mol for H_2O and -74.84 kJ/mol for CH_4 . The constants in the heat capacity equation : $C_p = a + bT + cT^2$ are given below where C_p is in kJ/mol/K and T in K.

Components	a	$b \times 10^3$	$c \times 10^6$
CO_2	26.54	42.454	-14.2979
H_2	29.082	-0.821	1.9917
CH_4	13.415	77.079	-18.7569
H_2O vapour	30.38	9.62	-1.19



11. a) Carbon monoxide and hydrogen reacts to give methanol : $\text{CO} + 2\text{H}_2 \longrightarrow \text{CH}_3\text{OH}$

The conversion of CO entering the reactor is only 20%. A feed stream consisting of 33% CO, 66.5% H_2 and 0.5% CH_4 is mixed with a recycle stream and send to a reactor. The methanol leaving the reactor is separated and the unconverted gases are recycled. To prevent the accumulation of methane and keep its concentration in the recycle stream at 3%, a portion of recycle stream is blown off. For 100 moles of fresh feed, determine the following :

- (i) the moles of recycle stream
 - (ii) the moles of purge stream
 - (iii) the composition of purge stream
 - (iv) the moles of methanol produced. 8
- b) Propane is burnt with excess air to ensure complete combustion. If 55 kg of CO_2 and 15 kg of CO are obtained when propane is completely burned with 500 kg air, determine the following :
- (i) the mass of propane burnt
 - (ii) the per cent of excess air
 - (iii) the composition of flue gas. 7
