

JK LAKSHMIPAT UNIVERSITY, JAIPUR

INSTITUTE OF ENGINEERING AND TECHNOLOGY

End Term Examination (Regular), Nov.-Dec. 2015

B. Tech in Chemical Engineering, 3rd Semester

Roll No.....

COURSE CODE: CHE301

Time: 3 hours

Max. Marks: 100

Instructions to students:

1. Do not write anything other than your roll number on question paper.
2. Assume suitable data wherever required and mention it clearly.
3. Writing appropriate units, nomenclature, and drawing neat sketches/schematics/ flow chart wherever, required are an integral part of the answer.

Q.1A Objective type multiple choice questions (10 questions @ 1 mark)

10

- i. Jules-second is a unit of
(a) Work (b) Pressure (c) momentum (d) Angular momentum
- ii. Wavelength of ray of light is 0.00006 m. It is equal to
(a) 0.6 micron (b) 6 micron (c) 60 micron (d) 600 micron
- iii. A force is given by $F = at + bt^2$ where t is the time, what is the dimension of a and b
(a) MLT^{-3} , MLT^{-4} (b) MLT^{-2} , MLT^{-3} (c) MLT^{-1} , MLT^{-2} (d) MLT^{-4} , MLT^{-3}
- iv. A bypass stream for a process is useful because
(a) It improve the conversion (b) It increases the product yield
(c) It ensure the batter control overs the process (d) None of these
- v. Clausius-Claypeyron equation is applicable in
(a) Mating process only (b) Vaporization Process only
(b) Sublimation Process only (d) All of these
- vi. Raoult's Law is applicable to
(a) Ideal solution (b) Real solution
(b) Mixture of water and alcohol (d) Non-ideal solution
- vii. N_2 content in a urea sample was found to be only 42%. What is the actual urea content of the sample? (molecular weight of urea = 60)
(a) 80% (b) 90% (c) 95% (d) 98%
- viii. A solution is made by dissolving 1 kilo mole of solute in 2000 kg of solvent. The molality of the solution is
(a) 2 (b) 1 (c) 0.5 (d) 0.05
- ix. An equation for calculating vapour pressure is given by, $\log_{10} P = A - B/(t + c)$. This is called the
(a) Kistyakowsky equation (b) Antonic equation
(c) Kopp's rule (d) Trouton's rule

- x. Concentration of a solution expressed in terms of _____ is independent of temperature.
 (a) molarity, (b) normality, (c) molality, (d) none of these

Q.2 Short answer type questions (4 questions @ 2.5 marks)

10

- The thermal conductivity of steel is 16.5 Btu/(h)(ft)(°F). What is the value of the thermal conductivity in W/(m)(°C)?
- An aqueous solution of sodium chloride is prepared by dissolving 20 kg of NaCl in 100 kg of water. Calculate weight % composition of the solution.
- Metal phosphoric acid is obtained by dissolving phosphorous pentoxide in cold water. What is the yield in kg of the metal phosphoric acid produced from 50 kg of P₂O₅ charge in the reactor?
- Calculate the heat that must be added to 5 kgmol of air to heat from 298K to 573K using mean molal heat capacity data for air given below.

Data: $C_{pm}^0 = 29.40 \text{ kJ / kgmol.K}$ for air between temperature range 298K to 573K

Q.3A A fuel gas consists of a mixture of CH₄ and N₂. This mixture is burnt with air.

05

The Flue gas analysis is:

CO₂=7.3%, O₂=6.9% and N₂=85.9%

Calculate the percentage of excess air and composition of fuel gas mixture.

Q.3B A gas mixture containing benzene vapour is saturated at 101.325 kPa and 323K (50°C). Calculate the absolute humidity if the other components of the mixture is (a) nitrogen and (b) carbon dioxide.

05

Q.4A What is Fundamental quantity and Derived quantities? Give units of following in terms of fundamental quantity: Area, Volume, Work, Power, Mass flow rate and Specific heat.

05

Q.4B The equation for the heat transfer from a stream of gas flowing in turbulent motion is as follows:

05

$$h = \frac{16.6 C_p G^{0.8}}{D^{0.2}}$$

Where

C_p = Heat capacity (Btu/(lb)(°F)), G = Mass velocity (lb/ft².s)

D = Internal diameter of pipe (m)

Convert this equation into SI unit and find out the new constant.

Q.5A 10,000 kg/h of solution containing 20% methanol is continuously fed to a distillation column. Distillate is found to contain 98% methanol and waste solution from the column carries 1% methanol. All percentage is by weight. Calculate:

05

(i) The mass flow rate of distillate and bottom product.

(ii) The percentage loss of methyl alcohol.

- Q.5B Calculate the energy required to dissociate 1 Kg of sodium bicarbonate at 298K (25°C). The dissociation reaction is: 05
- $$2\text{NaHCO}_3(s) \rightarrow \text{Na}_2\text{CO}_3(s) + \text{CO}_2(g) + \text{H}_2\text{O}(g)$$

Components	$\Delta H_f^0, \text{kg / mol}$ at 298.15K(25°C)
$\text{NaHCO}_3(s)$	-950.81
$\text{Na}_2\text{CO}_3(s)$	-1130.68
$\text{CO}_2(g)$	-393.51
$\text{H}_2\text{O}(g)$	-241.82

- Q.6A A gas mixture contains 0.28 kgmol of HCl, 0.34 kmol of N₂ and 0.09 kgmol of O₂. Calculation: 05

- (i) Average molecule weight of gas
(ii) Volume occupied by this mixture at 4atm and 303K.

- Q.6B It is required to make 100 kg of 30% NaOH solution by mixing the following liquids; 20% NaOH solution and 36% NaOH solution. Calculate the quantities of the two solutions to be mixed. 05

OR

- Q.6B A single effect evaporator concentrating a weak liquor containing 5% solids to 55% solids (by weight) is fed with 6000kg/h of weak liquor. Calculate: 05

- (i) Amount (in Kg) of water evaporate per hour and
(ii) Flow rate of thick liquor.

- Q.7A With a typical example, explain the terms: Conversion, Yield, Selectivity, Limiting component and Excess component. 05

- Q.7B Calculate the total pressure and composition of vapour in contact with the solution at 100°C containing 35% benzene, 40% toluene and 25% O-xylene by weight. Data: 05

Component	Vapour Pressure at 100°C(mmHg)	Molecular weight
Benzene	1340	78
Toluene	560	92
O-xylene	210	106

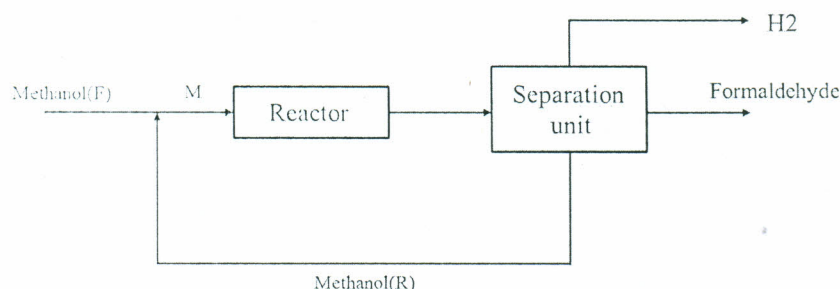
OR

- Q.7B The weather bureau reports a dry bulb temperature of ambient air as 29°C and relative humidity of 80%. The barometer read 750 mm hg. Calculate the percentage humidity of ambient air. (Vapor pressure of water at 29°C = 30 mm Hg.). 05

- Q.8A Formaldehyde is produced by dehydrogenation of methanol. 10
- $$\text{CH}_3\text{OH} \rightarrow \text{HCHO} + \text{H}_2$$

The per pass conversion is 67%. The product leaving the reactor is fed to separation unit battery where formaldehyde is separated from methanol and

hydrogen. The separated methanol is recycled to reactor. If the product rate of formaldehyde is 1000kg/h, calculate : (a) combine feed ratio and (b) flow rate of methanol required to the process as fresh feed.



Q.9A Define the following terms with reference to air-water humidification operation: 10

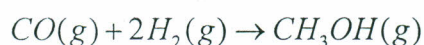
- (1) Dry-bulb temperature
- (2) Absolute humidity
- (3) Relative humidity
- (4) Humid heat
- (5) Dew point

Q.9B A stream containing 10% CH₄ and 90% air by volume is to be heated from 373K to 573K at a rate of 0.05m³ NTP per second. Calculate the heat required to be added using mean molal heat capacity data below: Data: 10

Gas	$C_{pm}^o (373-298K)$	$C_{pm}^o (573-298K)$
CH ₄	37.5974	43.0821
Air	29.2908	29.6132

OR

Q.9B Obtain an empirical equation for calculating the heat of reaction at any temperature T (in K) for the reaction: 10



Data: $\Delta H_R^0 = -90.41 \text{ kJ/mol}$, $C_p^0 = a + bT + cT^2 + dT^3, \text{ kJ/(mol.K)}$

Component	a	b $\times 10^3$	c $\times 10^6$	d $\times 10^9$
CO(g)	29.0277	-2.8165	11.6437	-4.7063
H ₂ (g)	28.6105	1.0194	-0.1476	0.769
CH ₃ OH(g)	21.137	70.843	25.86	-28.497

