

JK LAKSHMIPAT UNIVERSITY, JAIPUR
INSTITUTE OF ENGINEERING AND TECHNOLOGY
 End Term Examination (Regular/Backlog), November 2017
 B. Tech/ M. Tech (as applicable) in Chemical Engineering, Semester Third

Roll No.....

COURSE CODE: CHE301

Time: 3 hours

Max. Marks: 100

COURSE TITLE: Chemical Process Calculations

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.	The specific weight of a substance has the units (a) N/m ³ (b) kg/m ³ (c) N/m ² (d) kg/m ²	
ii.	Kinematic viscosity has the following dimensions (a) M ⁻¹ L ⁻¹ T ⁻¹ (b) L ² T ⁻¹ (c) L ⁻² T (d) MLT ⁻²	
iii.	Select the quantity in the following that is a dimensionless parameter (a) Specific gravity (b) Specific weight (c) Angular velocity (d) Specific volume	
iv.	A balanced chemical equation is in accordance with (a) Law of gaseous volumes (b) Law of Avogadro (c) Law of constant proportions (d) Law of conservation of mass	
v.	The symbolic representation of the molecules of a compound is called (a) Structural formula (b) Molecular formula (c) Empirical formula (d) Graphic formula	
vi.	A chemical reaction occurs when the energy of the reacting molecules is (a) Less than the activation energy of the reaction (b) Equal to the activation energy of the reaction (c) More than the activation energy of the reaction (d) Equal to or more than the activation energy of the reaction	
vii.	A reaction which proceeds with absorption of heat is termed as (a) Exothermic reaction (b) Endothermic reaction (c) Thermo-chemical reaction (d) Photochemical reaction	
viii.	A photochemical reaction is (a) Catalyzed by light (b) Used to convert heat energy into light (c) Initiated by light (d) Accompanied with emission of light	
ix.	If the oxygen is entirely removed from a fire by smothering it with foam, the combustion will : (a) Slow down (b) Stop entirely (c) Speed up (d) Not be affected at all	
x.	Combustion requires: (a) A supply of oxygen (b) A combustible fuel (c) A source of heat energy (d) All of the above	

- Q.2 Short answer type questions (4 questions @ 2.5 marks) (10)
- A. Explain the Hess's law.
- B. Define the standard heat of reaction.
- C. Convert 125 lb. /ft³ into g/cm³.
- D. Calculate the equivalent moles of Na₂SO₄ in 1288 g of Na₂SO₄·10H₂O Crystals.
- Q.3A Drive the correlation for ideal gas law, Dalton's law and Amagat's law. 05
- Q.3B By electrolyzing a mixed brine, a gaseous mixture is obtained at the cathode 05
having the following composition by weight: Cl₂=67%, Br₂=28%, O₂=5%.
Calculate (i) composition of the gas by volume (ii) Average molecular weight (iii)
Density of gas mixture at 298K and 1 atm.
- Q.4A Define the following terms absolute humidity, Saturated humidity and 05
percentage humidity.
- Q.4B Conditioned air at 760 mmHg total pressure, 50°C and at a humidity of 0.01kg 05
water per kg of bone dry air enters the drier. It leaves the drier at 760 mmHg
total pressure and 50°C, with relative humidity 83%. Vapour pressure of water
at 50°C is 92.5 mmHg. If 50 kg of water enters into the air stream per hour,
calculate the rate of bone dry air flowing through the dryer.
- Q.5A Drive the correlation for Molal heat capacity at constant pressure and heat 05
capacity at constant volume.
- Q.5B A distillation column separates 20% Benzene, 50% Toluene, and 30% Xylene into 05
95% benzene, 4% toluene and 1% Xylene and waste product containing 2%
Benzene. Calculate the quantities of distillate and residue if 1000 kgmol/h of
feed is fed.
- Q.6A Define the mixing and derive the correlation for mixing with suitable diagram. 05
- Q.6B A crystallizer is charged with 7500 kg of an aqueous solution at 377 K, 28.5% by 05
weight which is anhydrous sodium sulphite. The solution is cooled. During
cooling operation 5% of water originally present was lost. As a result, the
crystals of Na₂SO₄·10H₂O crystallize out. The mother liquor is found to contain
18.2 % by weight of anhydrous salt. Calculate the yield of crystals and quantity
of mother liquor.
- OR**
- Q.6B Fresh juice contains 14% solids and 86% water by weight and to be concentrated 05
to contain 42% solids by weight. In a single evaporator system, it is found that
the volatile constituents of juice escape with water leaving the concentrated juice
56%, with a flat taste. To overcome this problem part of the fresh juice bypass
the evaporator. Calculate:
(a) The fraction of juice that bypass the evaporator
(b) The concentrated juice produced containing 42% solids by weight.
- Q.7A Define the following terms limiting and excess reactant with suitable chemical 05
reaction

Q.7B Moist hydrogen containing 4 mole % water is burnt completely in a furnace with 30% excess air. Calculate the Orsat analysis of the flue gas. 05

OR

Q.7B A fuel oil contains 87% Carbon and 13% Hydrogen. It is burnt to form flue gas of following composition: Carbon dioxide 13.2%, Oxygen 3.8% and Nitrogen 83%. Calculate the percentage of excess air used. 05

Q.8A In a contact process for H_2SO_4 , a gas mixture of 8 volume% SO_3 and rest inert is sent to an absorption tower at the rate of 28 kgmol/hr. where it is contacted with 97.3% H_2SO_4 counter currently fed from top of the tower. 98.5% SO_3 is absorbed to produce 98 weight% H_2SO_4 . Part of this solution is withdraw as final product and the rest is mixed with 95.6% H_2SO_4 coming from an air drying tower to produce 97.3% H_2SO_4 , which is fed from top. Calculate:
 (a) Mass of 95.5% H_2SO_4 makeup acid required per hour
 (b) Mass of 97.3% H_2SO_4 fed from top of tower per hour.
 (c) Mass of 98% H_2SO_4 solution produced per hour
 (d) Recycle ratio. Assume physical absorption. 10

Q.9A Flue gas leaving the boiler stack at 700 K has the following composition on mole basis. Carbon dioxide 14%, Water 11%, Oxygen 3% and Nitrogen 72%. Calculate the heat lost in 50 kgmol of gas mixture above 350 K using heat capacity data given below: $C_p^o = a + bT + cT^2, kJ / kgmol \cdot K$ 10

Component	a	b x 10 ³	c x 10 ⁶
CO ₂	21.35	64.27	-41.01
H ₂ O	32.49	0.08	13.21
O ₂	26.01	11.76	-2.35
N ₂	29.60	-5.15	13.19

Q.9B Derive the correlation for heat capacity at constant pressure and constant temperature. And also derive the correlation for heat capacity of gases at constant pressure and mean Molal heat capacity. 10

OR

Q.9B Obtained an empirical equation for calculating the heat of reaction at any temperature for the following reaction. $CO + 2H_2 = CH_3OH$. $\Delta H_R^o = -21.59 kcal / mol$
 $C_p^o = a + bT + cT^2 + dT^3 cal / mol \cdot K$ 10

Component	a	b x 10 ³	c x 10 ⁶	d x 10 ⁹
CO	29.03	-2.82	11.64	-4.71
H ₂	28.61	1.02	-0.15	0.77
CH ₃ OH	21.14	70.84	25.87	-28.50

*****Good Luck*****