DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY, LONERE

End Semester Examination – Winter 2019

Course: B. Tech in Chemical /Petrochemical Engineering **Semester : V**

Subject Name: Chemical Engineering Thermodynamics-II **Subject Code: BTCHC 501**

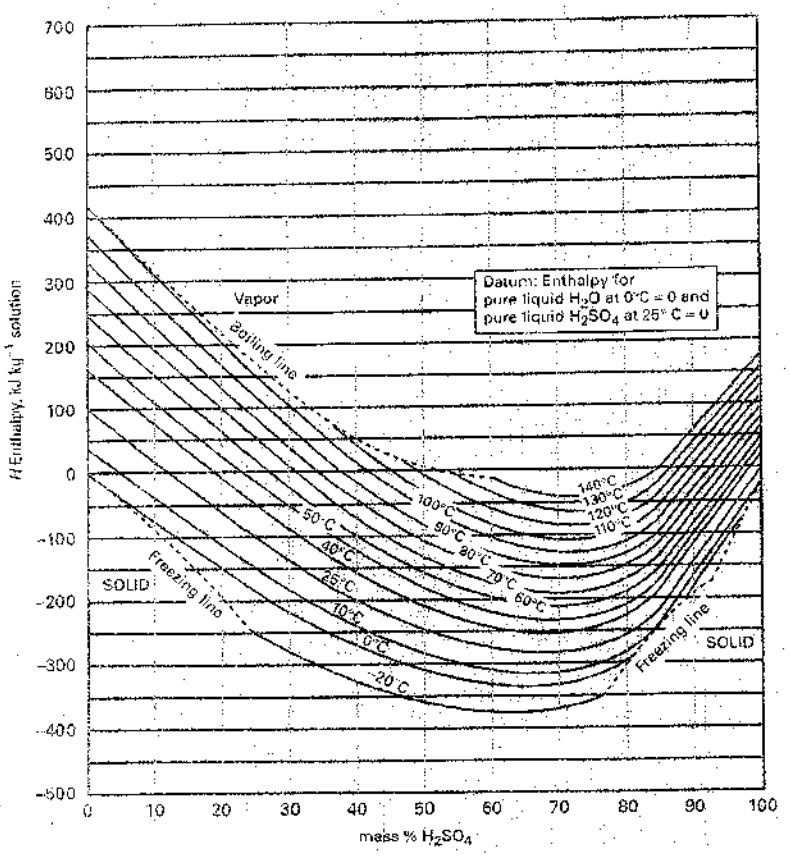
Max Marks: 60 **Date: 9/12/2019** **Duration: 3 Hr.**

Instructions to the Students:

1. *Solve ANY FIVE questions out of the following.*
2. *The level question/expected answer as per OBE or the Course Outcome (CO) on which the question is based is mentioned in ( ) in front of the question.*
3. *Use of non-programmable scientific calculators is allowed.*
4. *Assume suitable data wherever necessary and mention it clearly.*
5. *Use Steam table wherever required.*

		(Level/CO)	Marks
Q. 1	Solve **Any Two** of the following.		
A)	Assuming Raoult's law to be valid prepare a *T-x,y* diagram for a pressure of 100 kPa for the Benzene (1)/ethyl benzene(2) system. Show subcooled liquid region, superheated vapor region , and saturation temperatures of pure specie on T-x,y diagram.	(Apply)	06
B)	With neat sketch , explain the concept of retrograde condensation and its application to petroleum industry.	(Understand)	06
C)	A liquid mixture of cyclohexane (1)/Phenol(2) for which x_1=0.6 is in equilibrium with its vapor at 417.15 K. Determine the equilibrium pressure P and vapor composition y_1 from the following information.: $\ln\gamma_1 = A(x_2)^2$ $\ln\gamma_2 = A(x_1)^2$ At 417.15K, P_1^{sat} =75.20 and P_2^{sat} =31.66 kPa The system forms an azeotrope at 417.15 K for which $x_1^{az} = y_1^{az} = 0.294$	(Understand and apply)	06
Q.2	Attempt the following.		
A)	The enthalpy of binary liquid system of species 1 & 2 at T and P is given by $H = 400x_1 + 300x_1^2$ Find the value of $\bar{H}_1^{\infty}$ and $\bar{H}_2^{\infty}$.	(Apply)	06
B)	Derive an expression showing that chemical potential can be used as a criteria for phase equilibrium.	(Apply)	06
Q. 3	Solve the following.		
A)	The partial molar volume of methanol in a methanol (1)-water (2)solution at x_1 = 0.3881 is 39.176×10^{-6} m^3/mol. The density of the mixture is 905.376 kg/m^3. Determine the partial molar volume of water in the solution.	(Apply)	06
B)	Estimate the fugacity of cyclopentane at 110 °C and 275 bar. At 110°C the vapor pressure c cyclopentane is 5.267 bar. Molar mass of cyclopentane = 70, T_c= 511.8 °K , P_c =45.02 bar , Z_c = 0.273 , V_c =258 cm^3/mole and ω =0.196	(Apply)	06
Q.4	A) is compulsory. Solve one from either B) or C).		
A)	For the following system ,determine Margules parameters and then apply the Margules equation to sufficient number of VLE calculations to allow the construction of P-x,y diagram at a given temperature. **System : 2- Butanone(1)/ Toluene (2) at 50 °C**	(Apply)	08

H - x,y diagram for Q.5 A) to be attached with answer book.



Paper End

γ_1^{∞} =1.47 γ_2^{∞} = 1.30 P_1^{sat} =36.09 kPa P_2^{sat} = 12.30 kPa

B) A stream of nitrogen flowing at the rate of 2 kg/s and a stream of hydrogen flowing at the rate of 0.5 kg/s mix adiabatically in a steady flow process. If the gases are assumed ideal , What is the rate of entropy increase as a result of the process? (Apply)

C) Give the mathematical expression for Raoult's Law. State its the major assumptions. Give few examples of binary systems obeying Raoult's law with proper justification. (Remember)

Q. 5 Solve the following

A) Nine thousand kg/hr of an 80 mass% H_2SO_4 solution in water at 50°C is continuously diluted with chilled water at 5°C to yield a stream containing 50 mass% H_2SO_4 at 60°C . (Apply)

i) What is the mass flow-rate of chilled water in kg/hr?

ii) What is the rate of heat transfer in kJ/hr for the mixing process? Is heat added or removed?

iii) If the mixing occurred adiabatically , what would be the temperature of the product stream? Assume here the same inlet conditions and the same product compositions as for part (ii)

B) The equilibrium constant for the reaction A → B is doubled when the temperature is changed from 25 °C to 35 °C. Calculate the enthalpy change of the reaction. (Understand)

Q.6 Solve **Any Two** of the following :

A) The water gas shift reaction, (Analyze)

$$CO\,(g) + H_2O\,(g) \text{ ---------- } CO_2\,(g) + H_2\,(g)$$

is carried out under different sets of conditions described below. Calculate the fraction of steam reacted in each case. Assume the mixture behaves as an ideal gas.

i)The reactants consists of 1mol of H_2O vapor and 1 mol of CO. The temperature is 1100 K and the pressure is 1 bar.

ii)Same as i) except that pressure is 10 bar.

iii)The reactants are 2 mol of H_2O and 1 mol of CO other conditions are (assume ln K = 0 for above reaction)

B) For the ammonia synthesis reaction written : (Apply)

$$\frac{1}{2}N_2(g)+\frac{3}{2}H_2(g)\rightarrow NH_3(g)$$

with 0.5 mole of N_2 and 1.5 mole of H_2 as the initial amounts of reactants and with the assumption that the equilibrium mixture is an ideal gas, show that:

$$\varepsilon_e = 1-(1+1.299K\frac{P}{P^0})^{-1/2}$$

C) With neat sketch , write an informative account on fuel cell. (Remember)

Data : Antoine equation to be used is as follows :

$$\ln P^{sat}/kPa = A - \frac{B}{T/K + C}$$, Parameters for the Antoine Equation

Chemical Specie	A	B	C
Benzene	13.8594	2773.78	-53.08
Ethyl Benzene	14.0045	3279.47	-59.95

EC2FA3D0100FD3760E4B79796A99E316

DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY,
LONERE – RAIGAD – 402 103
Winter Semester Examination – Dec 2019

Branch: B.Tech (Chemical/Petrochemical) **Semester: V**
Subject with Subject Code:-Mass Transfer Operation-I (BTCHC502) **Marks: 60**
Date:-11/12/19 **Time: 3 Hrs.**

Instructions to the Students
1. Each question carries 12 marks.
2. Attempt **any five** questions of the following.
3. Illustrate your answers with neat sketches, diagram etc., wherever necessary.
4. If some part or parameter is noticed to be missing, you may appropriately assume it and mention it clearly.

(Marks)

Q.1. a In an air-carbon dioxide mixture at 298 K and 202.6 kPa, The concentration of CO_2 at two planes (3 mm) apart are 15 vol.% and 25 vol.%. The diffusivity of CO_2 in air at 298 K and 202.6 kPa is $8.2*10^{-6}$ m^2/s. Calculate the rate of transfer of CO_2 across the two planes, assuming: (4)

i. Equimolecular counter diffusion.

ii. Diffusion of CO_2 through a stagnant air layer.

b Give the Differences between two fluxes J_A and N_A. (4)
Write down the relationship between mass transfer coefficients and diffusivity with details.

c Describe in short the phenomena of equimolar counter diffusion and diffusion of one component through non diffusing other component with applications from Chemical Engg as well as real life. (4)

Q.2. a The equilibrium adsorption of benzene vapor on certain activated charcoal at 33 ^0C is reported as follows. (8)

Benzene vapor adsorbed cm^3/gm charcoal	Partial pressure benzene in mm Hg
15	0.001
25	0.0045
40	0.0251
50	0.115
65	0.251
80	1.00
90	2.81
100	7.82

Charcoal which has adsorbed upon it 100 cm^3 of benzene vapor per gm is to be stripped

		at the rate of 45.5 kg/hr of its benzene content to a concentration of 58 cm^3 adorbed benzene per gm of charcoal by continuous countercurrent contact with a ... am of pure nitrogen gas at 1 std atm. The temperature will be maintained at 33 ^{0}C. (i) What is minimum rate of nitrogen flow in kg/hr? (ii) What are number of ideal stages if nitrogen is 2 time minimum?	
	b	For an interphase mass transfer between gas and liquid phase, derive relation between overall and individual k type mass transfer coefficients w.r.t. gas phase and liquid phase. Use usual terminology.	4
3.	a	A coal gas is to be freed of its light oil by scrubbing with wash oil as an absorbentand the light oil recovered by stripping the resulting solution with steam. Thecircumstances are as follows: Absorber: Gas in, 0.250 m^3/s at 26^{0}C, P_t = 1.07*10^5 N/m^2, containing 2.0% byvolume of light oil vapors. The light oil will be assumed to be entirely benzene,and a 95% removal is required. The wash oil is to enter at 26 C, containing 0.005mole fraction benzene and has an average molecular weight 260. An oilcirculation rate of 1.5 times the minimum is to be used. Wash oil-benzenesolutions are ideal. The temperature will be constant at 26^{0}C. At 26 ^{0}C, the vapor pressure of benzene = 13330 N/m^2. Compute the oil circulation rate.	9
	b	Explain selection criteria for choice of solvent for absorption.	3
4.	a	Oil is extracted from crushed seeds by a low boiling hydrocarbon. The following experimental data are collected on the concentration and solid content of the underflow and solid content of the overflow and the solution retained in the underflow. The concentrations of both the streams are equal on solid free basis.	8

Overflow		Underflow
kg oil per kg clear solution	kg solid per kg solution	kg inerts per kg solution
0.0	0.0	0.67
0.05	0.002	0.66
0.2	0.005	0.64
0.25	0.007	0.625
0.30	0.01	0.60
0.35	0.013	0.58
0.40	0.017	0.55
0.45	0.022	0.51
0.50	0.029	0.46

		(i) Calculate and plot the equilibrium data on a suitable diagram. (ii) For ... ve problem, if 1000 kg of crushed seeds containing 25 % oil and 75 % inerts in intimately mixed with 1800 kg of the hydrocarbon and adequate time for settling is allowed. Calculate mass of underflow, mass of overflow and fraction of the oil removed in the extract.	
	b	Explain the procedure in brief how to find number of ideal stages in continuous countercurrent extraction(of type I) when solvent rate is given for given feed rate. Use triangular or rectangular or solvent free system for explanation.	4
Q.5.	a	Equilibrium adsorption data for propane on activated carbon at two different temperatures are given below. Fit the data using Langmuir isotherm & answer the following questions. What is the correlation coefficient (q_m) at temperature 310.9 K ? What is the correlation coefficient (K) at temperature 310.9 K ? What is the correlation coefficient (q_m) at temperature 366.5 K ? What is the correlation coefficient (K) at temperature 366.5 K	6

T=310.9 K		*T=366.5 K*	
p (kPa)	*q (m mol/g)*	*p (kPa)*	*q (m mol/g)*
2.27	1.044	21.07	1.677
15.6	2.819	45.33	2.386
31.74	3.48	93.34	2.954
89.74	4.207	279.2	3.584
293	4.9	461.9	3.922
479.2	5.294	634.3	4.244

	b	Write a short note on break through curve and mass transfer zone MTZ in adsorption.	3
	c	Explain application of Freundlich equation for adsorption with example on one stage and two stage adsorption.	3
Q.6.	a	Explain the following terms in brief with respect to tray towers(0.5X6) (i) Flooding (ii) Weeping (iii)Coning (iv) Overall efficiency (v) Point efficiency (vi) Murphree tray efficiency	3
	b	Describe sparged vessels and its applications in brief.	3
	c	Describe packed towers and its applications in brief.	3
	d	Describe construction and working of spray tower.	3

EC2PA3D0100PD3760B4B79796AE9C772

Q.6(a) The irreversible reaction A ⟶ B was carried out in a batch reactor and the following concentration- time data were obtained 4M

(b)

t (min)	0	5	8	10	12	15	17.5	20
C_A (mol/dm^3)	4	2.25	1.45	1	0.65	0.25	0.06	0.008

5M

(c) Determine the reaction order and specific reaction rate using differential method.

Discuss the steps in a Langmuir-Hinshelwood kinetic mechanism.

Discuss dissociative adsorption with proper example and develop Langmuir isotherm for the same.

t-Butyl alcohol was produced by the liquid phase hydration (W) of isobutene (I) over an amberlyst-15 catalyst. The system is normally a multiphase mixture of hydrocarbon, water and solid catalysts. However, the use of co-solvents or the excess TBA can achieve reasonable miscibility.
The reaction mechanism is believed to be

$$I + S \rightleftharpoons I{\bullet}S$$
$$W + S \rightleftharpoons W{\bullet}S$$
$$W{\bullet}S + I{\bullet}S \rightleftharpoons TBA{\bullet}S + S$$
$$TBA{\bullet}S \rightleftharpoons TBA + S$$

Derive a rate law assuming;
(i) The adsorption of isobutene is limiting.
(ii) The reaction follows Eley-Rideal kinetics

$$I{\bullet}S + W \rightleftharpoons TBA{\bullet}S$$

and that surface reaction is rate limiting.

Paper End

Dr. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY, LONERE

Winter End Semester Examination: December 2019

Course: B. Tech. Chemical/ Petrochemical Engineering — Semester: V
Subject : Chemical Reaction Engineering-I [BTCH503] — Marks: 60
Date: 13/12/2019 — Time: 03 Hrs.

INSTRUCTIONS TO THE STUDENTS

1. **Each question carries 12 marks.**
2. **Attempt any five Questions in all.**
3. **Illustrate your answers with neat sketches, diagrams etc. wherever necessary.**
4. **Necessary data is given in the respective questions. If such data is not given, it means that the knowledge of that part is a part of examination.**
5. **If some part of parameter is noticed to be missing, you may appropriately assume it and should mention it clearly.**

Q.1

(a) Give the informative account of different types of reactors used in industries with the design equations. 5M

(b) Attempt ANY ONE of the following 3M

(i) "Infinite reactor volume is necessary to reach complete conversion or equilibrium conversion', explain.

(ii) State true or false "the extent of reaction achieved in PFR does not depend on its shape". Justify your answer.

(c) The first order reaction A → B is carried out in a tubular reactor in which the volumetric flow rate is constant. Derive an equation relating the reactor volume to the entering and exiting concentrations of A, the rate constant k, and the volumetric flow rate v. Determine the reactor volume necessary to reduce the exiting concentration to 10% of entering concentration when the volumetric flow rate is 10 dm^3/min and specific reaction rate k is 0.23/min. 4M

Q.2 Attempt ANY THREE of the following 12

(a) A second-order liquid phase reaction $A \rightarrow B$ is taking place in an idea mixed flow reactor (MFR). The exit conversion through MFR is 50 %. What will be the exit fractional conversion through a new MFR which is 6 times larger than the original reactor? M

(b) A homogeneous gas phase decomposition reaction 4A → B + 7S takes place in an isothermal ideal plug flow reactor. The reaction rate is, $-r_A = k_1 C_A$ with k_1 = 0.17 s^{-1}; feed concentration of A (C_{Ao}) = 0.1 mol/m^3 Feed Flow rate (F_{Ao}) = 0.17 mol/s. What is the size of the reactor to achieve 50% conversion?

C7B584B90A6F2E4613757AB6D16E6B20

Give the informative account of space velocity and space time with appropriate example.

(c)

A 400 liter CSTR and 100 liter PFR are available to process 1.0 liter of feed per second. The feed contains 41% A, 41% B and 18% inerts. The irreversible gas phase reaction, $A + B \rightarrow C$
Is to be carried out at 10 atm and 227°C. The rate of reaction in g mol/lit min is given below as a function of conversion:

$-r_A$	0.2	0.0167	0.00488	0.00286	0.00204
X	0.0	0.1	0.4	0.7	0.9

What would be the overall conversion if two 400 liter CSTRs were connected in parallel with half of the feed going to each reactor?

(d)

Give informative account of space velocity and space time with appropriate examples. 4M

Q.3(a)

Set up a stoichiometric table for the following liquid phase reaction taking place inside a CSTR in the presence of H_2SO_4 (as a catalyst).
$CH_2 - O - CH_{2(l)} + H_2O_{(l)} \longrightarrow (CH_2OH)_{2(l)}$
The initial concentrations of ethylene oxide and water are 1 lbmol/ft^3 and 3.47 lbmol/ft^3, respectively. If the conversion of ethylene oxide is 50% then what is the final concentration of ethylene oxide and water.

(b) 3M

Give informative account of reaction order and molecularity.

(c) 5M

(i) Attempt ANY ONE of the following
The reaction $C_2H_{6(g)} + 2Br_{2(g)} \rightarrow C_2H_4Br_{2(g,l)} + 2\,HBr_{(g)}$
is to be carried out at 200°C and 2500 kPa. The vapour pressure of 1,2 - dibromoethane at 200°C is 506.5 kPa with k=0.01 lit^6/mol^{2}min. The reaction is

(ii) first order in ethane and second order in bromine. Calculate the conversion at which condensation begins.
The rule of thumb that the rate of reaction doubles for a 10°C increase in temperature occurs only at a specific temperature for a given activation energy. Show that the relationship between activation energy and temperature for which rule holds is

Q.4 (a) $$T = \left[\frac{10(K)E}{R \ln 2} \right]^{1/2}$$ 6M

Neglect any variation in concentration with temperature.

The elementary gas phase reaction
$(CH_3)_3COOC(CH_3)_3 \longrightarrow C_2H_6 + 2CH_3COCH_3$
is carried out isothermally in a flow reactor with no pressure drop. The specific reaction rate at 50°C is 10^{-4} min^{-1} and E=85kJ/mol. Pure di-tert-butyl peroxide

enters the reactor at 10 atm and 127°C and a molar feed rate of 2.5 mol/min.

(b) Calculate the reactor volume and space time to achieve 90% conversion in a 6M
(i) CSTR
(ii) PFR.

It is desired to design a CSTR to produce 200 million pounds of ethylene glycol per year by hydrolyzing ethylene oxide. However, before the design can be carried out, it is necessary to perform and analyze a batch reactor experiment to determine the specific reaction rate constant. Since the reaction will be carried out isothermally, the specific reaction rate will need to be determined only at the reaction temperature of the CSTR. At high temperatures there is significant by-product formation, while at temp. below 40°C the reaction does not proceed at a significant rate; consequently,, a temp of 55°C has been chosen. Since the water is usually present in excess, its concentration may be considered constant during the course of the reaction. The reaction is 1st order in ethylene oxide.
In the lab experiment, 500 ml of a 2M solution of ethylene oxide in water was mixed with 500 ml of water containing 0.9 wt % sulfuric acid. The temperature was maintained at 55°C. The concentration of ethylene glycol was recorded as a function of time. From the table determine the specific reaction rate at 55°C.

Q.5 (a)

Time, min	0.0	0.5	1.0	1.5	2.0	3.0	4.0	6.0	10
Conc. of ethylene glycol (kmol/m^3)	0.00	0.145	0.270	0.376	0.467	0.610	0.715	0.848	0.957

6M

The gas phase decomposition $A \longrightarrow B + 2C$
Is carried out in a constant volume batch reactor. Runs 1 through 5 were carried out at 100°C, while run 6 was carried out at 110°C.
(i) From the following data, determine the reaction order and specific reaction

(b) rate. 6M
(ii) What is activation energy for this reaction?

Run	1	2	3	4	5	6
Initial Conc. C_{A0} (gmol/dm^3)	0.025	0.0133	0.01	0.05	0.075	0.025
Half-life, $t_{1/2}$ (min)	4.1	7.7	9.8	1.96	1.3	2.0

3M

C7B584B90A6F2E4613757AB6D16E6B20

DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY, LONERE

Winter End Semester Examination – Dec. 2019

Course: B. Tech in Chemical Engg **Sem: V**

Subject: Chemical Technology (BTCHC505) **Marks: 60**

Date:-18/12/2019 **Duration:- 3 Hr.**

Instructions to the Students: 1. Illustrate your answers with neat sketches, diagram etc., wherever necessary.2. If some part or parameter is noticed to be missing, you may appropriately assume it and should mention it clearly **3. Attempt Any FIVE of the following**

		(Level/CO)	Marks
Q. 1	**Solve any two of the following**		12 M
(A)	Explain with neat schematic representation of the electrolysis of aqueous salt solution by the mercury, diaphragm and by the membrane process	CO1	
(B)	Explain difference between Unit Operation and Unit Process with examples		
(C)	Describe the manufacturing process of soda ash by modified Solvay process and discuss the corrosion problems encountered in this process.		
Q.2	**Solve the following**		12 M
(A)	Describe the manufacturing process of following with neat labeled flow sheet i) Phosphoric acid by electric furnace method ii) Ammonia by Hyber process	CO2	
Q. 3	**Solve any two of the following**		12 M
(A)	Describe production of sulfur by Frasch process with a) Raw Materials b) process Description c) process flow diagram d) Major Engineering Problem	CO2	
(B)	Explain the continuous hydrolysis and saponification process of soap production with respect to chemical reactions, flow diagrams		
(C)	With the help of neat flow sheet describe the manufacturing of sulphuric acid by contact process and discuss the uses of sulphuric acid.		
Q. 4	**Solve any two of the following**		12 M
(A)	Explain Extraction of sugar cane to produce crystalline white sugar with neat flow sheet ,process description, major engineering problem	CO3	
(B)	Production of Ethyl alcohol by fermentation with a) Raw Materials b) process Description c) process flow diagram d) Major Engineering Problem		
(C)	Short note on Fermentation products from petroleum.		
Q. 5	**Solve the following.**		12 M
(A)	How will you produce pulp by Kraft pulp process w.r.t. chemical reaction, process flow diagram and major engineering problems	CO3	

(B) Explain different manufacturing processes for Polymer, Ethenic polymer processes, Polycondesation Processes, Polyurethanes. 12 M

Q. 6 Solve the following.

(A) Describe production of crude petroleum and Refinery products. CO4

(B) Short note on Pyrolysis , cracking and Reforming

Paper End

DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY, LONERE

Winter Semester Examination – December 2019

Course: B. Tech in Chemical/Petrochemical Engineering

Subject Name: Food Technology **Subject Code:** BTCHE506-II(D)

Max. Marks:60 Date:20-12-2019 **Duration:- 3 Hr.**

Instructions to the Students:

1. **Answer any five questions**
2. **Necessary data required is provided in the respective questions**

		(Level/CO)	Marks
Q. 1	**Answer the following.**		
	Describe the world food demand and the Indian scenario. What are steps required for product and process development?	Remember	**12**
Q.2	**Answer<u>any one</u>the following.**		
(A)	Explain properties of foods and processing theory.	Remember	**12**
(B)	Write notes on **<u>any two</u>** of the following. (i) Basic Food Chemistry and microbiology (ii) Effects of processing on nutritional values (iii) Food safety and good manufacturing practices	Remember	**12**
Q.3	**Solve the following.**		
	Describe the ambient temperature process of food materials with regard to raw material preparation, size reduction, mixing and forming and separation of food components.	Remember	**12**
Q. 4	**Answer the following:**		
	Write notes on **<u>any two</u>** of the following: (i) Blanching and pasteurization using steam and air (ii) Heat sterilization using water and steam (iii) Baking and roasting	Remember	**12**
Q.5	**Answers the following**		
	Explain food processing by direct and radiated heat with emphasis on dielectric heating, ohmic heating and infrared heating.	Remember	**12**
Q.6	**Answer the following.**		
	Enumerate the post processing applications and packing of food materials.	Remember	**12**
	***** End *****		