Total No. of Printed Pages:2

SUBJECT CODE NO:- K-08

FACULTY OF ENGINEERING AND TECHNOLOGY

T.E. (Chem.) Examination Oct/Nov 2016

Process Equipment Design & Drawing - I

(Revised)

[Time: Three Hours] **[Max.Marks:80]**

Please check whether you have got the right question paper.

N.B
i. Question no. 01 and 06 are compulsory.
ii. Answer any two questions from remaining of each section.
iii. Assume suitable data if required.

Section A

Q.1 Answer following terms 10
a) Crevice corrosion.
b) Impost stresses.
c) Riveted joints
d) Advantages if lining a process equipment
e) Galvanic action.

Q.2 a) What are the essential properties of pipe coatings? 07
b) How is the radial stress and radial deflection estimated for a vessel which is subjected to external pressure? 08

Q.3 A thick walled (monobloc) high pressure vessel has 500mm inside diameter. It is subjected to an internal pressure of 600bar. The yield strength of material is 5000 kg/cm^2. The ultimate tensile strength of material is 6500kg/cm^2. Calculate the thickness if vessel according to the various theories of failure. Take factor of safety = 1.4. Also estimate the tangential stress & radial stress variation along the vessel wall. 15

Q.4 A loose type flange is to be designed to following specifications. 15
Outside diameter of shell = 80cm
Shell thickness = 10mm
Design pressure = 10kg/cm^2
Design temperature = 150°C. And the gasket is if asbestos composition
Inside diameter of gasket = 84cm
Gasket width = 1.6cm.
Gasket factor m = 2.75
Gasket seating stress =260 kg/ cm^2
Permissible stress for the bolt material = 950kg/cm^2
Permissible stress for the flange material = 950 kg/cm^2
32 bolts of 19 mm diameter are to be used to tighten the flange joints. Check whether the gasket is sufficiently wide to keep away from crusting .Calculat minimum thickness of flange.

Q.5 Write note on 15
a) Elastic instability
b) Nozzle reinforcement
c) Non – ferrous metals.

Section B

Q.6 Answer following term.

a) Stress due to bending moment 03
b) Double deck roof 03
c) Flexible coupling 04

Q.7 Give detail design procedure for designing skirt support and skirt – bearing plate. 15

Q.8 a) Explain in detail the design of self supported conical roof. 08
b) Give detail calculations for the estimation of nozzle diameter for drain in storage tank. 07

Q.9 A small quantity of salt solution is given into a mixing tank containing water. The mixing is done with six blades disc type turbine agitator. How long will it take to blend away salt solution, so that the concentration fluctuations are about the final value are not greeter than $\pm$0.1% tank is provided with baffles. 15

Turbine impeller diameter = 1.2m
Tank diameter D = 6m.
Liquid depth = 6m ρ_{liquid} = 1000kg/ m^3
Viscosity of liquid = $1 \times 10^{-3} n - s/m^2$
Impeller speed = $0.2 sec^{-1} = 12 rpm$.

Q.10 Write note on 15

a) Storage tank dike.
b) Safety measures in equipment design
c) Design of anchor bolts.

Total No. of Printed Pages:2

SUBJECT CODE NO:- K-29
FACULTY OF ENGINEERING AND TECHNOLOGY
T.E.(Chem) Examination Oct/Nov 2016
Chemical Reaction Engineering-II
(Revised)

[Time: Three Hours] **[Max.Marks:80]**

Please check whether you have got the right question paper.

N.B i) Q.No.1 and 06 are compulsory.
ii) Answer any two questions from remaining of each section.
iii) Assume suitable data, if required and draw neat sketches whenever needed.

Section A

Q.1 Explain following terms.
a) Steps involved in fluid particle reaction 03
b) Age distribution of fluid and RTD 04
c) Stimulus-response experiment 03

Q.2 a) Discuss the tank in- series model and compare this model with dispersion model. 10
b) Explain in detail concept of degree of segregation in mixing. 05

Q.3 a) For diffusion through Gas layer controlling derive expression for relation, for time required and conversion, assuming un-reacted core model for spherical particles of unchanging size. Also find time required for complete conversion. 12
b) Explain the relation between E, F and C curve. 03

Q.4 a) A feed consisting 30% of 50-μm-radius particles 40% of 100- μm-radius particles 30% of 200 μm-radius particles is to be fed continuously in a thin layer onto a moving grate crosscurrent to a flow of reactant gas. For the planned operating conditions the time required for complete conversion is 5, 10, and 20 min for the three sizes of particles. Find the conversion of solids on the grate for a residence time of 8 min in the reactor. 10
b) How will you determine rate controlling step in fluid-particle reaction 05

Q.5 Write note on. 15
a) Hydrodynamics flow model
b) Liquid film Enhancement factor.
c) Contacting pattern for fluid reaction.

SECTION-B

Q.6 Explain following terms

a) Characterization techniques for catalyst. 04
b) Adsorption isotherm 04
c) Effectiveness factor 02

Q.7 Discuss in brief about fluidized bed reactor reaction kinetics. 15

Q.8 An experimental rate measurement on the decomposition of A is made with a particular catalyst 15

a) Is it likely that film resistance to mass transfer influences the rate?
b) Could this run have been made in the regime of strong pore diffusion?
c) Would you expect to have temperature variations within the pellet or across the gas film?

Data
For the spherical particle:
dp=2.4mm or L=R/3=0.4mm=$4x10^{-4}$mcat
Effective mass conductivity = $5x10^{-5}$ m^3/hr. m cat
Effective thermal conductivity =1.6kJ/hr. m cat – K

For the gas film surrounding the pellet (from correlations in the literature):
h=160kJ/hr. m^2 cat K (heat transfer coefficient)
Kg=300m^3/hr.m^2 cat (mass transfer coefficient)

For the reaction:
Heat of reaction=-160kJ/mol A (exothermic)
CAg=20mol/m^3 (at 1 atm and 336°C)

$-r_{A\,obs}=10^5$ mol / hr. m^3 cat
Assume that the reaction is first order.

Q.9

a) Explain in detail Thiele modulus and effectiveness factor for porous catalysts 10
b) Discuss in details global rate of reaction 05

Q.10 Write note on. 15

a) Kinetic regimes in fluid- fluid reaction.
b) Slurry reactor
c) Method of preparing catalysts.

Total No. of Printed Pages:2

SUBJECT CODE NO:- K-59
FACULTY OF ENGINEERING AND TECHNOLOGY
T.E.(Chem) Examination Oct/Nov 2016
Mass Transfer Operations-II
(Revised)

[Time:Three Hours] **[Max. Marks:80]**

Please check whether you have got the right question paper.

N.B i) Q.No.01 & 06 are compulsory.
ii) Solve any two questions from remaining of each section A & B.
iii) Assume suitable data if necessary.

Section- A

Q.1 Explain the following. 10
i. Miscella
ii. Raffinate
iii. Principal of crystallization.
iv. Rotocel in leaching
v. Effect of solvent on extraction

Q.2 Explain the following. 08
a) Filter press leaching

b) Counter current multiple shank system. 07

Q.3 A Saturated solution of $Mgso_4$ at 354k is cooled to 303k in a crystallizer. During cooling 4% solution is lost by evaporation of water. Calculate the quantity of the original saturated solution to be fed to the crystallizer per 1000 Kg of $mgso_4.7\ H_2o$ crystals. 15
Solubility of $Mgso_4$ at 354 K =64.2 Kg/ 100 Kg water
Solubility of $Mgso_4$ at 303 k = 40.8 Kg / 100 Kg water

Q.4 a) Describe graphically and explain the concentrations in ternary system of liquid extraction. 05

b) Derive an equation for single stage liquid extraction. 10

Q.5 Write short note on. 15
i. Pulse column extractor.
ii. Os/o cooling crystallizer.
iii. HETP.

Section- B

Q.6 Explain the following. 10
a) Flash distillation
b) Weeping
c) Murphree plate efficiency
d) Rectifying section
e) Weirs.

2016

Q.7 The vapor pressure of n-Hexane & n-octane are given below ,obtain an empirical equation between X & Y for this system at constant presume of 101. 3kPa with the empirical equation generate vapor liquid equilibrium rate & construct a plot of X v/s Y comment the distribution diagram 15

Temp O_c	68.7	79.4	93.3	107.2	121.1	125.6
n^{po}Hexane Kpa	101.3	136.6	197.3	283.9	399.9	455.6
n^{po}octane Kpa	16.1	23.1	37.1	57.8	87.2	101.3

Q.8 A mixture of benzene & toluene containing 60 mole % benzene is to be separated to give a product of 95 mole % benzene and bottom product containing 05 mole% benzene. Feed enters a column at bubble point. It is proposed to operate a column with reflux ratio 2.5. find the theoretical plate require & feed plate vap. Liq. equilibrium data as 15

X	0	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Y	0	0.13	0.21	0.375	0.5	0.6	0.7	0.77	0.83	0.9	0.95	1.0

Q.9 Explain the method in detail for calculation of distillation column Mccabe Thiele method. 15

Q.10 Write notes on 15

i. Differential distillation
ii. Flash distillation
iii. Rectification on ideal plate

Total No. of Printed Pages:2

SUBJECT CODE NO:- K-89
FACULTY OF ENGINEERING AND TECHNOLOGY
T.E.(Chem) Examination Oct/Nov 2016
Plant Design & Process Economics
(Revised)

[Time:Three Hours] **[Max. Marks:80]**

Please check whether you have got the right question paper.

N.B 1) Question 1& 6 are compulsory. Solve any two from remaining questions in each section.
2) Assume suitable data & draw neat sketches whenever required.

Section A

Q.1 Solve define any five 10
1) Design engineer
2) Project report
3) Optimum economic diameter
4) Compound interest
5) Time value of money
6) Refrigerant

Q.2 a) What different methods of scale are up explain in detail? 08
b) What is principles of similarity criteria and scale equations for major equipment 07

Q.3 a) What is importance of plant location and write down factors involved in it. 10
b) What is plant layout write down different types of layout. 05

Q.4 a) Explain cash flow for industrial operations with neat tree diagram 10
b) What are different methods for calculating depreciation? Explain in detail. 05

Q.5 Write short note 15
a) Income taxes
b) Process auxiliaries
c) Optimum design

Section B

Q.6 Solve or define (any five) 10
1) Service life
2) Salvage value
3) Objective function
4) Non linear programming
5) Scheduling
6) Dummy

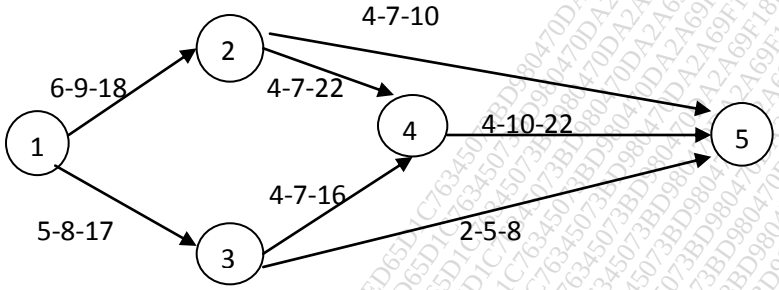
Q.7 a) How linear programming helps in solving optimization problems. Explain in detail. 10
b) Describe structural optimization and parametric optimization. 05

Q.8 a) Calculate annual rate of depreciation for 5 year recovery period asset such as a chemical plant using double declining balance method and half year convention and switching to straight line method on 10

remaining balance when it gives higher annual depreciation than that obtained with DDBM this is MACRS method.

b) What is depreciation explain in detail 05

Q.9 For network shown in fig time estimates (in days) each for activity are mentioned. Determine probability of completing project in 35 days by PERT method. 15



Q.10 Write short note 15

1) Project cost
2) CPM process
3) Break even chart

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Total No. of Printed Pages:2

SUBJECT CODE NO:- K-156
FACULTY OF ENGINEERING AND TECHNOLOGY
T.E.(Chem) Examination Oct/Nov 2016
Chemical Process Industries
(Revised)

[Time: Three Hours] **[Max. Marks:80]**

Please check whether you have got the right question paper.

N.B i) Question number 1 and 6 are compulsory.
ii) Answer any two questions from remaining of each section.
iii) Draw a well labelled diagram if necessary.

Section A

Q.1 Answer the following 10
a) State composition of natural gas.
b) What is triple superphosphate?
c) Mention industrial uses of sodium hydroxide
d) What are thermodynamic problems associated with ammonia manufacture?
e) Draw symbol for following unit operations:
i) Bucket elevator
ii) Magnetic separation

Q.2 a) Explain the terms: 05
i) Nitration
ii) Reduction
b) Describe the responsibilities of a chemical engineer in a process plant. 10

Q.3 a) What are three major components in a fertilizer? What are their roles? 05
b) With the help of a neat diagram describe manufacture of nitric acid. 10

Q.4 a) How producer gas is made? 05
b) Describe the process for sulphuric acid manufacture 10

Q.5 Write short notes on (any three) 15
a) Water gas
b) Diaphragm process for chlorine and caustic manufacture
c) Properties of super phosphate
d) Manufacture of oxygen.

Section B

Q.6 Answer the following: 10
a) Explain the term hydrogenation of oil
b) What is the use of bagasse?
c) Distinguish between hard and soft soap
d) State uses of starch
e) Enlist unit operations in paint manufacture

Q.7 a) What are properties of paper from Kraft process? 05
b) Describe manufacture of sugar from sugarcane 10

Q.8 a) State uses of polyvinyl chloride 05
b) With the help of a neat flow diagram, explain manufacture of ethylene 10

Q.9 a) Compare natural & synthetic rubber 05
b) Describe manufacture of vinegar 10

Q.10 Write short notes on (<u>any three</u>) 15
a) Varnishes
b) Cleaning action of soap
c) Polymeric oils
d) Starch manufacture

Total No. of Printed Pages:2

SUBJECT CODE NO:- K-178
FACULTY OF ENGINEERING AND TECHNOLOGY
T.E.(Chem.) Examination Oct/Nov 2016
Industrial Pollution & Control
(Revised)

[Time: Three Hours] **[Max. Marks:80]**

Please check whether you have got the right question paper.

N.B
i) Q.No.1 and Q.No.6 are compulsory.
ii) Attempt any two questions out of remaining in section A & B.
iii) Assume suitable data if required.

Section A

Q.1 Define the following 10
a) Smoke
b) Aerosol
c) Mixing height
d) smog
e) Stopping distance

Q.2 Explain in detail any two instruments used for gaseous pollutants analysis. Draw neat labelled sketches. 15

Q.3
a) What are the stationary & mobile sources of air pollutants? 07
b) A factory uses 2,00,000 lit/month of furnace oil of specific diversity 0.97 If for one million litters of oil is used for one year, the particulate matter emitted is 3.0 ton/year 502-59.7 ton/year NOx-7.5 ton/year hydrocarbon-0.52 ton/year. Calculate the height of chimney require to be provided for safe dispersion if pollutants. 08

Q.4 With a neat diagram explain the ESP & fabric filter. 15

Q.5 Write note on 15
i) Primary metrological parameters
ii) Plum behaviour
iii) Cyclone separator

Section B

Q.6 Define the following 10

a) Dissolved oxygen
b) Sludge age
c) Oxygen sag curve
d) Relative stability
e) Nitrification

Q.7 Explain with neat flow sheets 15

a) Removal of ammonia
b) Removal of phenol

Q.8 With neat sketch the working principle involved, construction & merits & demerits of thickening filter. 15

Q.9 a) What is the procedure to calculate COD give detailed equations? 10

b) Differentiate anaerobic & aerobic Process. 05

Q.10 Write note on 15

i) Streeter Phelps equation
ii) Classification of pollutants
iii) Aeration tank

Total No. of Printed Pages:2

SUBJECT CODE NO:- K-203
FACULTY OF ENGINEERING AND TECHNOLOGY
T.E.(CHEM) Examination Oct/Nov 2016
Chemical Reaction Engineering-I
(Revised)

[Time: Three Hours] **[Max. Marks:80]**

Please check whether you have got the right question paper.

N.B i) Q.No.1 from section A and Q.No.6 from section B are compulsory.
ii) Solve any two questions each from Section A and Section B.
iii) Assume suitable data if required.

Section A

Q.1 Define the following with examples:
(a) Rate of reaction 03
(b) Rate constant 03
(c) Third order reaction 04

Q.2 a. Differentiate between elementary and non elementary reactions. 05
b. Phosphor decomposes when heated according to following reaction: 10
$4PH_3(g) \rightarrow P_4(g) + 6H_2(g)$
At a given instant, the rate at which phosphor decomposes is $2.4x10^{-3}$ mole/lit sec.
(a) Express the rate in three different ways, using differential relation and show the relationship between them.
(b) What is the rate of formation of (i) P_4 (ii) H_2?

Q.3 Decomposition of acetone dicarboxylic acid is a first order reaction: 15
$Co(CH_2COOH)_2 \rightarrow CO(CH_3)_2 + 2CO_2$
Following is the data for the same

TK	273	293	313	333
$K_1(Sec)^{-1}$	$2.46x10^5$	$47.5x10^5$	$576x10^5$	$5480x10^5$

Find out the energy of activation for this reaction graphically.

Q.4 What are the different methods of determination of order of a reaction? Give the equations used for each one. 15

Q.5 Write notes on: 15
(a) Classification of reactions
(b) Constant-volume batch reactor
(c) Activation energy significance

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Section – B

Q.6 Define and give examples

(a) Space time 03

(b) Holding time 03

(c) Space velocity 04

Q.7 Explain in detail, what is the effect of temperature on equilibrium constant. 15

Q.8 Pure gaseous reactant $A(CA_0 = 100ppm)$ is fed at steady rate into MFR whose volume is 0.1 litter where it undergoes $2A \rightarrow R$. For different gas feed rates, the following data are obtained: 15

Pure No.	follow rate (lt/hr)	C_{AF} (PPM)
1	30.0	85.7
2	9.0	66.7
3	3.6	50
4	1.5	33.4

Find a rate equation for this reaction.

Q.9 a. Derive the design equation of steady state plug flow rector. 08

b. Explain the size compression of flow reactor. 07

Q.10 a. Explain the kinetics of first order reaction followed by zero order reaction. 08

b. Derive the performance equation for ideal batch reactor? 07

Total No. of Printed Pages:2

SUBJECT CODE NO:- K-303
FACULTY OF ENGINEERING AND TECHNOLOGY
T.E.(CHEM) Examination Oct/Nov 2016
Mass Transfer Operations-I
(Revised)

[Time: Three Hours] **[Max. Marks:80]**

Please check whether you have got the right question paper.

N.B i) Question No.1 and Q.No.6 are compulsory.
ii) Answer any two questions from remaining of each section.
iii) Figures to right indicate full marks.

Section A

Q.1 Answer the following.

a) According to penetration theory mass transfer coefficient is directly proportional to 02
i) D_{AB} ii) $D_{AB}^{\frac{1}{2}}$ iii) $D_{AB}^{-\frac{1}{2}}$ iv) D_{AB}^{2} 02

b) Very tall packed towers are divided into series of beds to
i) Reduce overall pressure drop ii) Avoid channelling iii) Reduce liquid hold up
iv) All of these 02

c) State Fick's first law of diffusion. 02

d) Milk powder is obtained by
i) Spray drier ii) Cylinder drier iii) Freeze drier iv) Open pan evaporator 02

e) Explain the term moisture content on wet basis.

Q.2 a) What is difference between eddy diffusion and molecular diffusion? 05
b) Derive an expression for finding mass flux of diffusion of A through non-diffusing B. 10

Q.3 Compare performance of sieve tray, bubble cap and packed bed column. 15

Q.4 a) With the help of a neat diagram, explain construction & working of a tunnel dryer. 05
b) Slacks of paper pulp 100cmx100cmx1.5cm is to be dried under constant drying condition from 66.7% to 30% moisture. The value of equilibrium moisture for the material is 0.5% if critical moisture content is 60% and rate of drying at critical point is 1.5 kg/hr/m^2. What is the drying time? The dry weight of each 2.5 kg. All moisture contents are on wet basis. 10

Q.5 Write short notes on:
a) Drying curve 05
b) Surface renewal theory 05
c) Packing used in packed column 05

Section – B

Q.6 Answer the following.

a) The absorption factor is defined as 02

i) Ratio of slope of equilibrium curve to that of operating line.

ii) Product of the slopes of the operating line and equilibrium curve

iii) Ratio of slope of operating line to that of equilibrium curve

iv) Reciprocal of product of slopes of operating line and equilibrium curve

b) Define relative humidity. 02

c) The adsorption of acetone vapour on activated carbon is 02

i) Highly endothermic process ii) Exothermic process iii) Slightly endothermic

iv) None of the above

d) What is adiabatic saturation temperature? 02

e) The dew point of an unsaturated mixture of water vapour and air at constant temperature & pressure. 02

i) Does not change with increase in time

ii) Increases with increase in absolute humidity

iii) Decreases with increase in absolute humidity

iv) Decreases linearly with increase in absolute humidity.

Q.7 a) What do you mean by height equivalent to an equilibrium stage? 05

b) An ammonia air mixture containing 2% by volume ammonia is to be scrubbed with water at 20^0C in a tower packed with 1.27 cm raschig rings. The water and gas rates are 1170kg/hr m^2 each based on empty tower cross section. What is height of tower required if 98% of ammonia in the entering gas is to be absorbed? The tower operates at 1 atmosphere pressure. The equilibrium relationship is given by equation $y_e = 0.746x$ where 10

y_e = mole fraction of ammonia air

x = Mole fraction in solution with water.

HTU=2m

Q.8 a) What are types of adsorption? 05

b) Discuss effect of temperature & pressure on adsorption. 10

Q.9 a) What is humidification and dehumidification? 05

b) In a process in which it is used as a solvent, benzene is evaporated into dry N_2 10
At 297 k and 101.3 KN/m^2 the resulting mixture has % humidity of 60. It is required to recover 80% of benzene by cooling to 283K and compressing to a suitable pressure. What should this pressure be? Vapour pressure of benzene is 12.2 KN/ m^2 at 297 k and 6.0 KN/ m^2 at 283 k.

Q.10 Write short notes on:

a) Molecular sieve 05

b) Properties of solvent used in absorption 05

c) Design of cooling tower 05

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Total No. of Printed Pages:1

SUBJECT CODE NO:- K-236

FACULTY OF ENGINEERING AND TECHNOLOGY

T.E.(Chem) Examination Oct/Nov 2016

Material Science & Technology

(Revised)

[Time: Three Hours] **[Max. Marks:80]**

Please check whether you have got the right question paper.

N.B i) Q.No.1 and Q.No.6 are compulsory.
ii) Solve any two questions from remaining question in each section.
iii) Draw neat sketches and assume suitable data whenever needed.

Q.1		Define following term	10
	1)	Interplanar spacing	
	2)	FCC structure	
	3)	quantum states	
	4)	Electron affinity	
	5)	Non crystalline state	
Q.2	a)	What is periodic table. Explain in detail with neat sketches.	10
	b)	Describe Hydrogen bonding.	05
Q.3	a)	What is powder method of structure determination. How it works.	10
	b)	Draw and explain cubic structure.	05
Q.4	a)	What is covaleatly Bonded structure, write down its properties.	10
	b)	Define coordination number and packing efficiency.	05
Q.5		Write short note	15
	1)	Metallic Bonding	
	2)	Miller Indices and planes	
	3)	Properties of Metallic Bonded Structures.	

Section-B

Q.6		Define following terms	10
	1)	stages of creep	
	2)	Brittle fracture	
	3)	Absolute permeability	
	4)	Magnetic potential	
	5)	Cathodic protection	
Q.7	a)	What are different heat treatment. Write down their applications in chemical industries.	08
	b)	What is creep and write down its types.	07
Q.8	a)	Write down different Electrical properties of materials.	08
	b)	What is hysteresis and write down its Role in material science.	07
Q.9	a)	Write down classification of materials.	08
	b)	What are different Non-metal and write down their application.	07
Q.10		Write short note	15
	1)	Graphite	
	2)	Laws of magnetic force	
	3)	Creep curve.	

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Total No. of Printed Pages:2

SUBJECT CODE NO:- K-268
FACULTY OF ENGINEERING AND TECHNOLOGY
T.E.(Chem) Examination Oct/Nov 2016
Chemical Engineering Thermodynamics
(Revised)

[Time: Three Hours] **[Max. Marks:80]**

Please check whether you have got the right question paper.

N.B i) Q.No.1 and Q.No.6 are compulsory.
ii) Answer any two questions from the remaining of each section.
iii) Assume suitable data, if required and draw neat sketches whenever needed.

Section A

Q.1 Explain following terms. 10
i. Gibb's Free Energy.
ii. Henry's Law.
iii. Fugacity coefficient.
iv. Compressibility factor.
v. Excess thermodynamic properties.

Q.2 a) Define Joule – Thomson coefficient and prove that it is zero for ideal gas. 08
b) Derive the Clausius - Clapeyron equation and state its application in thermodynamics. 07

Q.3 a) Explain in detail excess properties in thermodynamics and derive expression for excess Gibb's free energy. 08
b) Prove that the alternative definition of chemical potential is $\mu_i = [\partial U/\partial ni]$ at constant entropy, constant volume and constant number of mole other constituents. 07

Q.4 a) Calculate the fugacity of nitrogen gas at 800 bar from following data at 273 K. 07

P in bar	50	100	200	400	800	1000
PV/RT	0.98	0.986	1.03	1.23	1.76	2.01

b) The partial fugacity of component 1 in the binary liquid mixture of components 1 and constituents 2 at 298 K and at 20 bar is given as $50X_1 - 80X_1^2 + 40X_1^3$. Where partial fugacity is in bar and X_1 is mole fraction of component 1. Determine fugacity of pure component 1 Henry law constant and activity coefficient. 08

Q.5 Write note on. 15
i. Gibb's Helmholtz equation.
ii. Calculation of fugacity from residual volume.
iii. Mollier diagram.

Section B

Q.6 Explain following terms. 10
i. Relative Volatility.
ii. Chemical potential.
iii. Reaction coordinate.
iv. Giauque function.
v. Minimum boiling azeotrope.

Q.7 a) Using criteria of phase equilibrium show that the osmotic pressure over an ideal solution can be calculated as $P_{osmotic} = RTX_A/V_B$ 10
Where X_A: mole fraction of solute and V_B: molar volume of solvent.

b) Construct and explain the P-x-y diagram for binary system. 05

Q.8 a) Give details VLE calculations for flash vaporization. 07

b) Explain Raoult's law and prove that if Raoult's law is valid for one constituents of a binary solution over the whole concentration range, it must also apply to the other constituent. 08

Q.9 a) Following reaction occurs in a mixture consisting of 2 mol methane, 1 mol water, 1 mol CO_2 and 4 mol hydrogen initially. 07

$CH_4 + H_2O \rightarrow CO + 3H_2$

Deduce expression relating the mole fraction of various species to the extents of reaction.

b) What are the factors that are affecting the equilibrium conversion in chemical reaction equilibrium? Explain them in details. 08

Q.10 Write note on. 15

i. Phase rule for reacting system.

ii. NRTL equation.

iii. Phase equilibria in multicomponent system.