2014-15
B.TECH. (IV SEMESTER) EXAMINATION
CHEMICAL ENGINEERING
ENGINEERING CHEMISTRY & MATERIAL SCIENCE
(AC-211)

Maximum Marks: 60 Credits: 04 Duration: Three Hours

Answer all the questions. All questions carry equal marks.

Q.No. Question M.M.
1(a) Draw Body Centred Cubic (BCC), Face Centred Cubic (FCC) and Hexagonal Closed
Packed (HCP) structures. Calculate the atomic packing factor and number of atoms
present in the unit cell of each system. [5]
(b) What are crystal imperfections? Give different types of crystal imperfections. Describe the
effects of crystal imperfections on the properties of engineering materials. [5]
2. What is stainless steel? Give the general composition, properties and uses of different
types of stainless steel. [10]

OR

2’ Differentiate between steel and cast iron. Give the properties, composition and uses of
unalloyed gray cast iron and ductile cast iron.
3(a) Giving suitable examples, explain the terms phase, component and degree of freedom.
Discuss the different types of reactions involved in binary systems. [6]

OR

3’ (a) What is a solid solution? How are they classified? Discuss the different types of solid
solutions.
3(b) Discuss the phase diagram of Cu-Zn system. [4]
4(a) What are the objectives of heat treatment of metals and alloys? Explain the principle of
heat treatment and also mention the stages involved in the process of heat treatment. [5]
4(b) Discuss any two of the followings:
   (i) Annealing

   Contd...2.
5 Discuss any two the following techniques:
   (i) DSC
   (ii) SEM
   (iii) TEM

6 (a) Describe the Hittori's method for the determination of transport number.

   (b) Explain the Bronsted-Lowry Concept of acids and bases. Give its superiority over Arrhenius theory.

   (e) Derive the expression for the relative strength of two weak acids in terms of their dissociation constants.

   OR

   (e') The dissociation constants of formic acid and acetic acid are $21.4 \times 10^{-3}$ and $1.81 \times 10^{-5}$ respectively. Calculate the relative strengths of two acids.
Q.No. M.M.
1. Draw neat and well labelled rheological diagrams for two and three parameter models. Explain any five models in detail. [12]
2. (a) Derive hydrostatic law for a fluid in static position. Obtain the pressure height relationship for the troposphere of standard atmosphere up to 11 km above the earth's surface. State clearly the assumptions made. In the troposphere the temperature follows a lapse rate of 0.6°C/km. [08]
2. (b) Derive the equations for simple, inverted, and inclined U-tube manometers. [04]
3. (a) Define and derive the relationship for vorticity and circulation of flow. Find out the circulation for irrotational vortex flow pattern. [09]
   (a') Derive Hagen Poiseuille equation for flow inside a pipe. Discuss the formation of boundary layer inside a pipe for laminar as well as turbulent flow. Discuss boundary layer separation for convergent and divergent flows. [09]
3. (b) Explain streamline, streakline and pathline. [03]
   (b') Explain partial, total and material time derivatives. [03]
4. (a) The pressure drop ($\Delta P$), generated by a pump of a given geometry is known to depend upon the impeller diameter (D), the rotational speed (N), the fluid discharge (Q), the fluid density ($\rho$) and viscosity ($\mu$). Establish a relationship amongst these parameters using Rayleigh Theorem in the form of suitable dimensionless groups. Explain the significance of each of the dimensionless groups thus formed. [08]
   OR
contd... 2
(a') The capillary rise $h$ of a liquid in a tube varies with tube diameter $d$, gravity $g$, fluid density $\rho$, surface tension $\sigma$, and the contact angle $\theta$. (a) Find a dimensionless statement of this relation. (b) If $h = 3$ cm in a given experiment, what will $h$ be in a similar case if the diameter and surface tension are half as much, the density is twice as much, and the contact angle is the same?

4. (b) Flow through a heat exchanger tube is to be studied by means of a $\frac{1}{10}$ scale model. If the heat exchanger normally carries water, determine the ratio of pressure losses between the model and prototype if

(i) Water is used in the model.

(ii) Air at normal temperature and pressure is used in the model.

\[ \mu_{\text{air}} = 1.8 \times 10^{-5} \text{ kg m}^{-1} \text{ s}^{-1}, \mu_{\text{water}} = 1.6 \times 10^{-3} \text{ kg m}^{-1} \text{ s}^{-1}, \rho_{\text{air}} = 1.23 \text{ kg m}^{-3}, \rho_{\text{water}} = 1000 \text{ kg m}^{-3}. \]

OR

(b') A large tank open to the atmosphere is filled with water up to a height of 5 m from the outlet tap near the bottom of the tank. The tap is now opened, and water flows out from the smooth and rounded outlet. Determine the water velocity at the outlet.

5. (a) Classify the flow meters into variable head and variable area meter. Discuss any flowmeter in detail and derive the expression for the volumetric flow rate of the fluid using that flow meter.

5. (b) Explain what is meant by available and required net positive suction head (NPSH), cavitation, and specific speed of a centrifugal pump. Draw a neat and well labelled diagram of forward curved blade centrifugal pump.
B.TECH. (WINTER SEMESTER) EXAMINATION
CHEMICAL ENGINEERING
MATERIAL SCIENCE AND ENGINEERING MATERIALS
CH-223

Maximum Marks: 60
Credits: 04
Duration: Three Hours

Answer all the questions.
Notations used have their usual meaning.

Q.No. Question M.M.
1(a) What do you understand by ‘periodicity’ in crystalline substance? Discuss its various forms. [04]
1(b) Explain ‘Edge Dislocation’ in a crystalline material with the help of a diagram. [05]
1(c) Define ‘crystal direction’ and ‘crystal plane’ and show the direction of [1 1 1], [1 1 1/2] and [2 2 2] in a cubic crystal. Also, determine the Miller Indices of a plane making an intercept of 1, 2, 3 on crystal axes a, b, c respectively. [06]

OR

1'(a) The potential energy ‘W’ of a system of two atoms varies as a function of their distance of separation ‘r’ as follows:

\[ W = \frac{A}{r^n} + \frac{B}{r^m} \]

Show that at equilibrium:

i. \[ r = r_0 = \left( \frac{n}{m} \right) \frac{B}{A} \]

ii. Bond energy, \[ W_0 = \frac{A}{r_0^n} \left( \frac{n-m}{m} \right) \]

1'(b) Describe the various levels of structure of a material. [04]
1'(c) Determine the Packing factor for Simple Cubic and Face Centered Cubic unit cell. [05]

2(a) Draw a pressure-temperature diagram for one component system of iron. Apply phase rule to this system and find out degrees of freedom at different regions of contd....
the phase diagram. Also write the salient features of the diagram in brief.

OR

2(a') Discuss the formation of coarse pearlite, fine pearlite and bainite with the help of TTT diagram for austenite to pearlite transformation in steel.

2(b) What do you understand by 'cooling curve' and how are phase diagrams obtained?

3(a) Write down the classification of Non Ferrous alloys along with examples. How is the White Cast Iron converted into Malleable Cast Iron?

OR

3(a') Give a classification of Engineering Materials on the basis of nature and method of production.

3(b) What is mild steel? Discuss its limitations along with its uses in the process industry.

4(a) Explain Intergranular corrosion with the help of an example. How can it be prevented in 18/8 steel?

4(b) Write short notes on the following:
   i. Factors affecting the rate of corrosion
   ii. Constituents of Paint
2014-15
B.TECH. (WINTER SEMESTER) EXAMINATION
CHEMICAL ENGINEERING
PROCESS INSTRUMENTATION
CH-224

Maximum Marks: 60
Credits: 04
Duration: Three Hours

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.
Be precise.

<table>
<thead>
<tr>
<th>Q.No.</th>
<th>Question</th>
<th>M.M.</th>
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</thead>
<tbody>
<tr>
<td>1(a)</td>
<td>Define and briefly explain the static characteristics of instruments.</td>
<td>[08]</td>
</tr>
<tr>
<td>1(b)</td>
<td>What is uncertainty analysis? Derive the expressions for additive functions and product functions. Give the reasons why it is carried out? A resistor has a nominal stated value of 15 ( \Omega \pm 1% ). A voltage is impressed on the resistor, and the power dissipation is to be calculated in two different ways: (1) from ( P = E^2/R ) and (2) from ( P = EI ). Calculate the uncertainty in the power determination in each case when the measured values of ( E ) and ( I ) are: ( E = 150 \text{ V} \pm 1% ) (for both cases), ( I = 12 \text{ A} \pm 1% ). Which way of calculating power dissipation would you recommend and why?</td>
<td>[07]</td>
</tr>
<tr>
<td>2(a)</td>
<td>For the following \textbf{any three} devices, mention: (a) the input variable to the transducer, (b) output variable of the transducer, and (c) the principle of operation in brief.</td>
<td>[3x2=06]</td>
</tr>
<tr>
<td>i.</td>
<td>Thermopile</td>
<td></td>
</tr>
<tr>
<td>ii.</td>
<td>Bourdon gauge</td>
<td></td>
</tr>
<tr>
<td>iii.</td>
<td>Piezo electric device</td>
<td></td>
</tr>
</tbody>
</table>
iv. Doppler frequency shift ultrasonic flowmeter
v. Hot Wire Anemometer
vi. Venturimeter

2(b) Explain with an appropriate circuit diagram and relevant equations, the principle of any one of the following:

i) DC Wheatstone bridge using a very high input impedance differential amplifier.

ii) Basic Wheatstone bridge for potential measurement.

2(c) In a certain process equipment, there are three variables of interest namely, liquid level, pressure and temperature. It is required that an alarm is given out when any of the following combination of conditions occur among these variables:

1. Low level with high pressure
2. High level with high temperature
3. High level with low temperature and high pressure

The alarm will be triggered when the Boolean alarm variable will go to the logic true state (1). It is assumed that set point values have been assigned to each variable so that the Boolean variables are either 1 or 0 as the physical quantities are above or below the set point values.

Define a Boolean expression with AND operations that will give an alarm for each condition. Derive a final logic equation and develop a digital circuit using AND/OR gates that would perform the indicated operations.

OR

2(e') Give the significance of a DAC in process industries. How does a bipolar DAC differ from a unipolar DAC? What is meant by the conversion resolution of a DAC?

A control valve has a linear variation of opening as the input voltage varies from 0 to 15 V. A microprocessor outputs a 16-bit word to control the valve opening using a 16-bit DAC to generate the valve voltage. Find:

a) The reference voltage required to obtain a 3/4 open valve.

b) The percentage of valve opening for a 2-bit change in the input word.
3 Write notes on any **three** of the following:
   i) Doppler Shift ultrasonic flow meter
   ii) Transit time ultrasonic flow meter
   iii) Elastic element pressure transducers
   iv) Mcleod gage
   v) Laws of thermoelectricity
   vi) Classification of temperature measurement devices with examples

4 (a) Identify the following symbols as used in a P &ID:

   i)  
   ii)  
   iii)  
   iv)  
   v)  
   vi)  
   vii)  
   viii)  
   ix)  
   x)  

4(b) What are the different methods of composition analysis? Explain any **one** such method in detail.
B. TECH. WINTER (IV SEMESTER) EXAMINATION
CHEMICAL ENGINEERING
ENGINEERING BIOLOGY
CH 225

Maximum Marks: 60 Credits: 04 Duration: Three Hours

Answer all the questions.
Draw neat and self explanatory labelled diagrams wherever necessary
Symbols used have their usual meaning unless specified otherwise.

1(a) Describe three important factors on which the enzyme activity depends upon.

1(b) Derive the material balance equation over a cell in a CSTR (Chemostat). Also define the symbols used in the equation.

OR

1* With the help of a neat diagram discuss in detail the various phases of a bacterial cell life (batch growth curve). Derive the equation for important phases. Also define the terms Growth Associated Products (GAP), Non-Growth Associated Product (NGAP) and Mixed Growth Associated Product (MGAP).

2(a) With the help of a process flow diagram describe the manufacture of Chitosan.

OR

2(a') Differentiate between Secondary and tertiary structure of proteins.

2(b) List twenty amino acids classifying each of them into non-polar R group and polar R group.

3(a) Discuss post transcription modification and Post translational modification.

3(b) With the help of a neat flow diagram describe the recombinant-DNA technology.

OR

contd... 2.
3(b) With the help of a neat sketch describe the morphology of bacteriophages. Also mention the type of nucleic acid and the number of strands in each case.

4(a) Briefly describe the major characteristics of three different micro-organisms.

4(b) Describe in detail the industrial production of penicillin with the help of a process flow diagram. Also mention various unit operations and processes used.

OR

4(b') Describe the bioremediation of oil field waste in detail.
B.TECH. (WINTER SEMESTER) EXAMINATION
NUMERICAL METHODS IN CHEMICAL ENGINEERING
COURSE 226

Maximum Marks: 60
Credits: 04
Duration: Three Hours

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q.No. Question M.M.
1(a) Use the Regula Falsi method to compute the root of the equation 07
\[ \cos(2 \theta) \cdot e^x = 0 \]
1(b) The Hazen-Williams equation governing gravity flow down circular pipes is of the form: 08
\[ Q = 0.28C_{D}^{0.663} S^{0.54} \]
Where:
- \( Q \) = Flow Rate (273)
- \( C \) = Pipe Roughness coefficient (110)
- \( D \) = Pipe Diameter
- \( S \) = Pipe Gradient (0.0023)

The diameter of pipe is estimated to be about 10. Perform 3 iterations of Newton-Raphson method to improve this estimate.

OR

1’ Solve the following system of equations: 15
\[ 10X_1 + X_2 + X_3 = 12 \]
\[ X_1 + 10X_2 + X_3 = 12 \]
\[ X_1 + X_2 + 10X_3 = 12 \]

Using Gauss-Jordan elimination method.

2 Solve the following system of equations: 15
\[ 2X_1 - X_2 = 7 \]
\[ -X_1 + 2X_2 - X_3 = 1 \]
\[ -X_2 + 2X_3 = 1 \]


Cont'd on 2.
3(a) Estimate the value of Sin θ at 0°-25° using Newton's forward difference interpolation formula with the help of following table:

<table>
<thead>
<tr>
<th>θ</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sin θ</td>
<td>0.1736</td>
<td>0.3420</td>
<td>0.5000</td>
<td>0.6428</td>
<td>0.7660</td>
</tr>
</tbody>
</table>

3(b) A missile is launched from a ground station. The acceleration during its first 80 seconds of flight, as recorded, is given in the following table:

<table>
<thead>
<tr>
<th>t(sec)</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td>a(m/s²)</td>
<td>30</td>
<td>31.63</td>
<td>33.14</td>
<td>35.23</td>
<td>37.56</td>
<td>40.33</td>
<td>43.12</td>
<td>46.69</td>
<td>50.61</td>
</tr>
</tbody>
</table>

Calculate the velocity of the missile when t=80 seconds, using Simpson's 1/3 rule.

4(a) Solve the following differential equation

\[
\frac{dy}{dx} = x^2 + 3
\]

with the initial condition y(0) = 2, estimate y(1.5) using Euler's Method using with h=0.25

4(b) A body of mass 2 kg is attached to a spring with a spring constant of 10. The differential equation governing the displacement of the body y and time t is given by

\[\frac{d^2y}{dt^2} + 2\frac{dy}{dt} + 5y = 0\]

Find the displacement of the body y at time t=1.5 using Heun's formula given that y(0)=2 and y'(0)=-4

OR

4' Solve the following differential equation

\[
\frac{dy}{dt} = t + y
\]

with the initial condition y(0)=1 using Runge-Kutta fourth order method from t=0 to t=0.4 taking h=0.1
2014 - 2015
B.TECH. WINTER (IV SEMESTER) EXAMINATION
(ELECT. / CHEMICAL / MECH. / PETRO-CHEMICAL ENGINEERING)
COMMUNICATION SKILLS
(HU – 202)
Credits: 04

Maximum Marks: 40
Duration: Three Hours

Note: Answer all questions.
All questions carry equal marks.

UNIT – I

1. Write a persuasive letter to the prospective buyers of luxurious flats being developed in Greater Noida with all modern facilities. Try to convince the buyer with interesting and attractive offers. [98]

OR

Write a job application and create your CV in response to an advertisement that you recently saw in a national newspaper.

UNIT – II

2. Define and craft any two of the following business messages assuming appropriate business situations:
(a) Tender and Bid
(b) E-mail
(c) Press Notice
(d) Memo

UNIT – III

3. Make note or write an abstract of the following passage:

The real estate sector continues to confront liquidity issues owing to subdued demand and restricted debt funding. However, private equity (PE) funds have continued to gain strength as an alternate source of funding. PE fund inflows into the real estate sector in the first quarter of calendar 2015 grew 8% per cent to Rs.51.65 crore, of which the residential sector attracted 53 per cent.

A study by real estate consultancy Cushman & Wakefield attributed the increase to improved market sentiments and higher investments in residential and commercial office assets.

The report said, “The only city to see investment in commercial office in the first quarter of 2015. However, it said leased office assets such as IT parks and IT-SEZs are likely to gain significant interest from foreign investors “due to low risks, ongoing high occupancy levels along with stable rental yields, and significant potential for capital value appreciation. In addition, the introduction of REITs (real estate investment trusts) in India is likely to boost investments as investors may now have an exit route.”

During the period, residential assets recorded the second highest PE investment since 2008 with total value of investments in residential sector 2.5 times more than the year ago figure at Rs.27,732 crore. The total investment in commercial office assets was at Rs.12,416 crore, up 66 per cent. It was the third highest investment in the commercial office sector since 2008.

“With improving macro-economic conditions, enabling policy environment, recovering demand, attractive valuations and increasing capital requirements of the Indian real estate sector, PE funds are likely to increase their investments in the next few years,” Sanjay Dutt, Executive Managing Director, South Asia, Cushman & Wakefield said in a statement.

“However, the PE funds are likely to take only calculated risks and collaborate strictly with renowned developers to protect their investments.”

The report said that although the number of deals during the quarter fell to 19 from 18, average deal size more than doubled to Rs.320 crore from Rs.150 crore.
UNIT – IV

4. How will you maximize your performance in a job frequently asked questions in job interviews? Attempt to answer two of such questions.

OR

Write the transcript of a telephonic conversation you had with the student advisor of a foreign university discussing your prospect of admission for M.S. and also the different options available for financial support there.

UNIT – V

5. Generate a group discussion choosing ONE of the following topics with at least FOUR participants:

(a) Reservation in jobs is doing more harm than good for the country.
(b) Privatization of health care will improve the quality of health care facility.
(c) Government should give more incentives to the farmers to ensure food security.
2014-15
B.TECH. (WINTER SEMESTER) EXAMINATION
PETROCHEMICAL ENGINEERING/ CHEMICAL ENGINEERING THERMODYNAMICS
PK-212N/CH-221

Maximum Marks: 60
Credits: 04
Duration: Three Hours

Answer all the questions.
Use of graph paper is allowed
Notations used have their usual meaning.

Q.No. Question

Q1(a) Differentiate any two-
(i) Expression of work and Heat for Isothermal and Reversible Adiabatic process
(ii) First law and second law of Thermodynamics

Q1(b) Suppose 1 mole of an ideal gas has undergone a change of state from \((P_1, V_1, T_1)\) to \((P_2, V_2, T_2)\). The two different paths connecting the initial and final state are
(i) Constant volume process followed by isothermal expansion.
(ii) Constant pressure process followed by isothermal compression.
Derive the expression of per mole of entropy change for these two paths, and hence prove that entropy is a state function.

Q1(c) Heat is transferred to 10Kg of air which is initially at 100kPa and 300K until its temperature reaches 600K. Determine the change in internal energy, the change in enthalpy, the heat supplied, and the work done in the following process:
(i) Constant volume process
(ii) Constant pressure process

Assume that air is an ideal gas for which the \(P-V-T\) relationship is \(PV=nRT\), where \(n\) is the number of moles of the gas and \(R\) is the ideal gas constant. Take \(C_p=29.099 \text{kJ/mol K}\), \(C_v=20.785 \text{kJ/mol K}\) and molecular weight of air=29.
Q1(d) A particular power plant operates with a heat-source reservoir at 623.15 K (350°C) and a heat-sink reservoir at 303.15 K (30°C). It has a thermal efficiency equal to 55% of the Carnot-engine thermal efficiency for the same temperatures.

(i) What is the thermal efficiency of the plant?
(ii) To what temperature must the heat-source reservoir be raised to increase the thermal efficiency of the plant to 35%? Again thermal efficiency is 55% of the Carnot-engine value.

OR

Q1'(a) What is the perpetual motion machine of second kind? Discuss the limitations of first law of thermo dynamics.

Q1'(b) A reversible engine operating between a reservoir at 600 K and ambient atmosphere at 300K drives a refrigerator operating between 240K and the ambient atmosphere. Determine the ratio of energy rejected by both the devices to the ambient atmosphere to the energy absorbed by the engine from the reservoir at 600K.

Q1'(c) An ideal gas, initially at 303.15 K (30°C) and 106 kPa, undergoes the following cyclic processes in a closed system:

(i) In mechanically reversible processes, it is first compressed adiabatically to 500 kPa, then cooled at a constant pressure of 500 kPa to 303.15 K (30°C), and finally expanded isothermally to its original state.

(ii) The cycle traverses exactly the same changes of state, but each step is irreversible with an efficiency of 80% compared with the corresponding mechanically reversible process. Calculate Q, W, ΔU, and ΔT for each step of the process and for the cycle. Take Cp = (7/2)R and Cv = (5/2)R.

Q1'(d) During Summer there is an increased demand of ice to cool soft drink bottles in various shops. It is desired to produce ice at 0°C at the rate of 5000Kg/hr from water at 10°C. The ambient temperature is 40°C. To operate the refrigerating machine it is planned to supply power from heat engine. The heat engine operate
between the ambient atmosphere and a source at 100°C which is supported by solar heating panels. Calculate the minimum power required for operating the refrigerating unit, the maximum possible efficiency of the heat engine and the ratio of energy rejected to the ambient atmosphere to the energy absorbed from the water at 0°C. The latent heat of fusion of water at 0°C is 6.002 KJ/mol and the molar mass of water is 18 x 10^3 KJ/mol.

Q2(a) Show that for an ideal gas entropy change of mixing is always positive and mixing is an irreversible process.

Q2(b) The excess Gibbs energy of a binary liquid mixture at T and P is given by:

\[ G^\beta/RT = (-2.6x_1 + 1.8x_2) x_1 x_2 \]

(i) Find expressions for \( \ln \lambda_1 \) and \( \ln \lambda_2 \) at T and P.
(ii) Show that when these expressions are combined in accord with Summability equation the given equation for \( G^\beta/RT \) is recovered.
(iii) Show that \( (d \ln \lambda_1 / dx_1)_{x_2=1} = (d \ln \lambda_2 / dx_1)_{x_1=0} = 0 \).

OR

Q2(b)' At 300K and 1 bar, the volumetric data for a liquid mixture of Benzene and Cyclohexane are represented by \( V = 109.4 \times 10^{-6} - 16.8 \times 10^{-6}X - 2.64 \times 10^{-5}X^2 \), where X is the mole fraction of Benzene and V has the units of \( m^3/mol \).
(i) Find expressions for the Partial molar volumes of Benzene and Cyclohexane.
(ii) Show that when these expressions are combined in accord with Summability equation the given equation for V is recovered.

Q3(a) Define Bubble Point, Dew Point and Tie Line. Draw a typical T-x-y and P-x-y diagram and show sub cooled liquid, superheated vapors and Liquid-Vapor mixture regions, dew point curve, bubble point curve, boiling points of pure components, and vapors pressure of pure substances on them.
Q3(b) Binary System Acetonitrile(1)/Nitromethane(2) conforms closely to Raoult's law. [10]
Vapor Pressures for the Pure species are given by the following Antoine equation:

\[
\ln P_{1}^{0} = 14.2724 - (2945.47 / T - 49.15)
\]

\[
\ln P_{2}^{0} = 14.2043 - (2972.64 / T - 64.15)
\]

(i) Prepare a graph showing \( P \) vs \( x \) and \( P \) vs \( y \) for a temperature of 348.15 K.
(ii) Prepare a graph showing \( t \) vs \( x \) and \( t \) vs \( y \) for a Pressure of 70 kPa.
(iii) What will be the equilibrium liquid and vapour composition of Acetonitrile/Nitromethane at 348.15 K and 60 kPa.

Q4(a) What is standard Gibb's free energy change of a chemical reaction? Prove that [07]
Standard Gibb's free energy change is related to the equilibrium constant by the relation.

\[
\ln K = - \Delta G^0 / RT
\]

Q4(b) Derive the relationship between mole fraction of species in multiple reactions and [08]
the extent of reactions, also calculate the equilibrium constant at 298K of the reaction:

\[
N_2O_4(g) \rightarrow 2NO_2(g)
\]

Given that standard free energies of formation at 298 K are 97,540 J/mol for \( N_2O_4 \)
and 51,310 J/mol for \( NO_2 \).

OR

Q4(b)' The reaction \( N_2 + O_2 \rightarrow 2NO \) takes place in the gas phase at 2700°C and [08]
2025 kPa. The reaction mixture initially comprises 15 mole% oxygen, 77 mole% nitrogen and rest inert. The standard Gibb's free energy change for reaction is 113.83 kJ/mol at this temperature. Assuming ideal gas behaviour, calculate partial pressures of all species at equilibrium.