MCH-013

ASSIGNMENT BOOKLET

M.Sc. in Chemistry/Analytical Chemistry Programme (MSCCHEM/MSCANCHEM)

GENERAL PHYSICAL CHEMISTRY

(Valid from 1st July 2026 to 30th June 2027)

It is compulsory to submit the assignment before filling in the examination form

School of Sciences
Indira Gandhi National Open University
New Delhi-110068
(2026-2027)

Dear Learner,

Please read the section on assignments in the Programme Guide for M.Sc. in Chemistry that we sent you after your enrolment. A weightage of 30 per cent, as you are aware, has been earmarked for continuous evaluation, which would consist of one tutor-marked assignment for this course. The assignment is in this booklet and covers both the blocks of the course. The total marks of all the parts are 100, of which 40% are needed to pass it.

Instructions for Formatting Your Assignments

Before attempting the assignment please read the following instructions carefully:

1. On top of the first page of your answer sheet, please write the details exactly in the following format:

ENROLAMENT NO. :…..………

NAME :…………………...

ADDRESS :……………………

COURSE CODE :……………..

COURSE TITLE :……………..

ASSIGNMENT NO :……………..

STUDY CENTRE :…………….. **DATE :…………….**

(Name and Code)

PLEASE FOLLOW THE ABOVE FORMAT STRICTLY TO FACILITATE EVALUATION AND TO AVOID DELAY.

2. Use only foolscap size paper (but not of very thin variety) for writing your answers.
3. Leave about 4 cm margin on the left, top and bottom of your assignment response sheet.
4. Your answers should be precise.
5. Submit the complete assignment answer sheets within the due date.
6. The assignment answer sheets are to be submitted to your Study centre within the due date. Answer sheets received after the due date shall not be accepted.
   We strongly suggest that you retain a copy of your answer sheets.
7. This assignment is valid from 1st July, 2026 to 30th June, 2027. If you have failed in this assignment or fail to submit it by June 2027, then you need to get the assignment for the year 2027-2028 and submit it as per the instructions given in the Programme Guide.
8. You cannot fill the examination form for this course until you have submitted the assignment.

Wishing you good luck

Tutor Marked Assignment
GENERAL PHYSICAL CHEMISTRY (MCH-013)

Course Code: MCH-013
Assignment Code: MCH-013/TMA/26-27
Maximum Marks: 100

Note: Attempt all questions. The marks for each question are indicated against it.

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1. Answer ***any five*** of the following in brief: **(2x5 = 10)**

(a) State the mathematical expression for the Clausius inequality and outline its significance in thermodynamics.

(b) Define the term "dominant configuration" as used in statistical thermodynamics.

(c) Explain the physical significance of Gibbs energy (G) in terms of maximum useful work.

(d) Briefly describe the concept of proton hopping (Grotthuss mechanism) in aqueous solutions.

(e) Differentiate between a permutation and a configuration for a system of particles.

(f) State the law of constancy of interfacial angles in crystallography.

(g) What is the "improper rotation" of molecules? Explain this symmetry element using a suitable example.

2.

(a) Using combinations of internal energy change (ΔU) and entropy change (ΔS), determine the conditions for spontaneity and equilibrium for a process occurring at constant temperature (T) and constant volume (V) for the following cases: **(5)**

(i) $\Delta U < 0$ and $\Delta S > 0$
(ii) $\Delta U > 0$ and $\Delta S < 0$
(iii) $\Delta U < 0$ and $\Delta S < 0$
(iv) $\Delta U > 0$ and $\Delta S > 0$
(v) $\Delta S = 0$

(b) **(i)** Calculate the change in Helmholtz energy (ΔA) for the isothermal expansion of 3 mol of an ideal gas at 350 K from an initial volume of 10 L to a final volume of 25 L. (Given: R = 8.314 J K^{-1} mol^{-1}) **(3)**

(ii) Define the term "chemical potential" (μ) and explain its physical significance in systems of variable composition. **(2)**

3.

(a) Formulate the expression for the Boltzmann distribution function. List the fundamental constraints operative in its derivation and describe the role of Lagrange's method of undetermined multipliers. **(5)**

(b) **(i)** Consider a system with three discrete energy levels: ε_0, ε_1 and ε_2 with degeneracies of 1, 3 and 5, respectively. Write the expression for the molecular partition function (q) for this system. **(2)**

(ii) Derive the mathematical expression for the vibrational partition function, q_{vib}, of a diatomic molecule. **(3)**

4.

(a) **(i)** A compound is formed by two elements, X and Y. Atoms of element Y form a cubic close-packed (CCP) lattice, while atoms of element X occupy 1/4th of the octahedral voids. Determine the chemical formula of the compound. **(3)**

(ii) Differentiate between a primitive cubic cell and a body-centered cubic cell. **(2)**

(b) **(i)** Represent the following Miller indices planes within a cubic unit cell: (100), (211) and (101). **(3)**

(ii) Identify the symmetry elements present in a *trans*-1,2-dichloroethene molecule. **(2)**

5.

(a) Provide a detailed explanation of Transition State Theory (TST). How does the rate constant (k) derived from this theory relate to the Arrhenius equation? **(5)**

(b) **(i)** Discuss the Lindemann-Christiansen mechanism for unimolecular reactions and explain the role and formation of the "active molecule." **(3)**

(ii) Identify and explain the two important features of the expression for the rate of activation as per RRK theory. **(2)**

6. Answer ***any five*** of the following in brief: **(2x5)**

(a) Define partial molar volume and explain its physical significance in multicomponent systems.

(b) Differentiate between diffusion-controlled and activation-controlled reactions in solution.

(c) Describe the "secondary salt effect" and its impact on the rate constant of a reaction.

(d) Explain the significance of the intercept and slope in a Lineweaver-Burk plot for enzyme kinetics.

(e) What is the role of the solvent in the Debye-Hückel model of an electrolyte solution?

(f) Briefly describe the "lock and key" hypothesis of enzyme action.

(g) State Stirling's approximation and discuss its significance in the statistical mechanics of systems with a large number of particles.

7.

(a) Derive the mathematical expression for the rate constant of a reaction in solution using the encounter pair description. **(5)**

(b) **(i)** Name one experimental method used to study fast reactions other than the stopped-flow method. **(1)**

(ii) Describe the principle and experimental setup of the Relaxation method (e.g., Temperature-jump) for determining the rates of fast reactions. **(4)**

8.

(a) Derive the Michaelis-Menten equation for enzyme-catalyzed reactions. Define the Michaelis constant (K_m) and state its significance. **(5)**

(b) **(i)** Briefly define non-competitive enzyme inhibition to distinguish it from other types of inhibition. **(1)**

(ii) Derive the rate expression for uncompetitive enzyme inhibition and describe its impact on the Lineweaver-Burk plot. **(4)**

9.

(a) **(i)** List the fundamental assumptions of the Debye-Hückel theory for strong electrolytes. **(2)**

(ii) Calculate the ionic strength (I) of a mixed electrolyte solution containing 0.15 mol kg^{-1} of $Al_2(SO_4)_3$ and 0.10 mol kg^{-1} of NaCl. **(3)**

(b) **(i)** List the various experimental methods used for the determination of activity coefficients. **(2)**

(ii) Explain the principle of determining activity and activity coefficients through solubility measurements. **(3)**

10.

(a) **(i)** State the primary limitations of the phenomenological approach when describing transport properties. **(2)**

(ii) Using Fick's first law of diffusion, derive the mathematical expression that links the phenomenological and thermodynamic treatments of the diffusion phenomenon. **(3)**

(b) **(i)** Explain why molar conductivity (λ_m) is a more suitable quantity than simple conductivity (κ) for comparing the conduction behavior of different electrolytic solutions. **(2)**

(ii) Describe the effect of temperature on the thermal conductivity of gases. Explain why thermal conductivity is independent of pressure at moderately high pressures. **(3)**