PHYSICAL AND ANALYTICAL CHEMISTRY

ENSH 205

Lecture : 3 **Year : II**
Tutorial : 1 **Part : I**
Practical : 3

Course Objectives:
The objective of this course is to provide fundamental concept of general physical chemistry and analytical chemistry along with the application of analytical and instrumental techniques in the field of chemical engineering.

1 States of Matter (2 hours)

1.1 Van der Waals equation of state (no derivation, qualitative idea only)
1.2 Critical phenomena of gas: critical temperature, critical pressure and critical volume, (only qualitative idea with numerical), Isotherm of carbon dioxide gas, Principle of quantinuity of states

2 Liquefaction of Gas (2 hours)

2.1 Uses of freezing mixture, Joule Thompson effect, adiabatic expansion involving mechanical work, cooling by adiabatic demagnetization, Uses and handling of liquid nitrogen

3 Solution (16 hours)

3.1 Concentration of solution in different unit, activity and activity coefficient, pH of mixture of solution and buffer solution, ionic strength and related numerical, salt hydrolysis and pH of resulting solution
3.2 Ideal and non-ideal solutions, partially and completely miscible liquids (concept of critical solution temperature and mutual solubility temperature), general concept of azeotropic solutions
3.3 Fractionating column, Nernst distribution law (qualitative idea only), its applications and limitations, related numerical
3.4 Henry's law (solution of gases in liquid), its applications and limitations, related numerical, Colligative property; Raoult's law and related numerical

4 Basic Thermodynamics (5 hours)

4.1 Concept of internal energy, enthalpy, entropy, bond energy, properties of Gibbs free energy, criteria of spontaneity in terms of enthalpy and entropy

4.2 Thermodynamic quantities of cell reaction from emf (ΔG, ΔH, ΔS and K_{eq}), relation between electrical and chemical energy (ΔG = -nFE)

5 Chemical Kinetics (5 hours)

5.1 Rate of reaction and rate law equation, differential and integral rate law equation for zero, first and second order reaction

5.2 Fundamental concept of parallel reaction, consecutive reaction and opposing reaction (only differential equation), chain reaction

6 Basic Concept of Chemical Analysis (5 hours)

6.1 Qualitative and quantitative analysis, good laboratory practice, laboratory management and laboratory safety

6.2 Analytical balance, Analytical methodology, interference and its minimization, destructive and non-destructive method of analysis.

6.3 Accuracy and precision, sensitivity, limit of detection, limit of quantification, linear range, confidence limit and reliability of data, properties of Gaussian curve, analytical validation

7 Instrumental Method of Analysis (10 hours)

7.1 Electrochemical analysis, Importance of electrochemical analysis, different types of electroanalytical techniques (Qualitative idea), pH metry, conductometry, potentiometry and voltammetry

7.2 Microscopic analysis, Optical microscopy vis a vis electron microscopy: Field emission scanning electron microscopy, scanning probe microscopy, scanning tunneling microscopy, atomic force microscopy (Concepts, applications and limitations)

7.3 Chromatographic analysis, principle and application (Thin layer chromatography and high-performance liquid chromatography)

7.4 Ray analysis, application of x-ray analysis (X-ray photoelectron spectroscopy, X-ray fluorescence, X-ray photoelectron spectroscopy)

Tutorial (15 hours)

1. Application of gases phenomena in chemical engineering
2. Study of crystallography of different minerals found in Nepal
3. Operation of UV-VIS spectrophotometer, its applications and limitations
4. Lab visit: Instrumental lab visits

Practical (45 hours)

1. Calibration of volumetric equipment (Volumetric flask, burette, pipette, measuring cylinder)
2. Determination of band-gap of ZnO nanoparticles (provided)
3. Study the miscibility of phenol-water system at room temperature

4. Study the UV-VIS absorption spectra of a dye (Methylene blue, rhodamine, etc.) and determine the wavelength at maximum absorbance
5. Preparation of a TLC plate and determine the Rf values of given substance
6. Determination of equilibrium constant of KI + I2 ⇌ KI3 by distribution method
7. Carry out conductometric titration between the mixture of hydrochloric and acetic acids against standard sodium hydroxide solution
8. Verification of Beer-Lambert's law. Determination of the concentration of colored solution of unknown strength using filters colorimeter/spectrophotometer
9. Determination of heat of neutralization of strong acid and strong base by calorimetric method
10. To determine the concentration of phosphoric acid in cola beverage using pH meter (Some related experiments can be designed as per the laboratory availability)
11. Determination of pH of different solutions (buffer solution, soap solution, detergent solutions, green tea, black coffee, soil, aerated drinks, fruits juice)
12. Determination of critical micelle concentration of surfactant by surface tension measurement method
13. Study the XRD pattern of given rocks (Quartz, dolomite, haematite)

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1 and 2	4	6
3	16	24
4	5	6
5	5	6
6	5	6
7	10	12
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

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4. Skoog, D. A. & West, D. M. (2013). Fundamentals of Analytical Chemistry. Cengage Learning.
5. Christian, G. D. (2013). Analytical Chemistry. Wiley.
6. Skoog, D. A. (1998). Principles of Instrumental Analysis. Saunders College Publishing, Philadelphia, London.

7. Silverstein, R. M. & Webster, F. X. (2003). Spectroscopic Identification of Organic Compounds, John Wiley, New York.
8. R.A. Day and A. L. Underwood, Quantitative Analysis, Prentice-Hall of India, 1993.
9. Gautam, S. D., Prasad, M. K. & Bhattarai, D. P. (2013). Fundamental Chemistry, For B.Sc. First Year, Heritage Publishers & Distributors Pvt. Ltd.
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